BOARD OF EDUCATION

ILLUSTRATED CATALOGUE OF THE COLLECTIONS IN THE SCIENCE MUSEUM

SOUTH KENSINGTON

WITH DESCRIPTIVE AND HISTORICAL NOTES

MACHINE TOOLS

1920

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PREFACE.

The Science Museum, with its Collections and Library, aims at affording illustration and exposition in the fields of mathematical, physical, and chemical science, as well as their applications to astronomy, geophysics, engineering, and to the arts and industries generally. To that end the Museum includes objects which are of historical interest as marking important stages in development and others which are typical of the applications of science to current practice.

A Museum of Science was contemplated as an integral part of the Science and Art Department from its beginning in 1853, and in 1857 collections illustrating foods, animal products, examples of structures and building materials, and educational apparatus, were brought together and placed on exhibition.

The first of the Engineering Collections, that of Marine Construction, was formed in 1864, when the Royal School of Naval Architecture was established at South Kensington, and the ship models belonging to the Admiralty were transferred to the Museum from Somerset House where they had been previously. This collection of ships of war was of great historical interest, and with the assistance of private donors and by purchase it was rapidly increased by the addition of many models of mercantile ships as well as of later ships of war, with the result that when the Admiralty removed their models to the Royal Naval College, Greenwich, in 1873, an important collection still remained at South Kensington.

Engineering and Manufactures were first included in 1867, from which time the development of this portion of the Museum advanced steadily; but the transfer of the Museum of the Patent Office to the Department of Science and Art in 1883 added to the collection many machines of the highest interest in the history of invention and made it one of prime importance.

The collections of scientific instruments and apparatus were first formed in 1874, but it was only after 1876 that they became of importance. The Special Loan Collection of Scientific Apparatus which was held in that year in London brought together examples of all kinds from various countries, and a large number of these were acquired for the Museum.

In 1893, many Mining and Metallurgical objects, the collection of many years, were transferred to South Kensington from the Museum of Practical Geology in Jermyn Street, and these have subsequently been largely added to.

Mention should be made too of certain special Collections. The Watt Collection was presented to the Patent Museum in 1876 and contains original models made by James Watt; the Maudslay Collection consisting of models of marine engines and machine tools was purchased in 1900; and in 1903 a valuable collection of engine models, portraits, &c. was bequeathed by Bennet Woodcroft.

The Museum Collections are being continually added to by gifts and loans, and also by the purchase of such examples as are required to illustrate the application of science and the development of various types of instruments, machinery, &c.

NOTES.—A large number of objects in the Collections have been photographed. Selected prints from the negatives may be seen in guard books at the entrance stiles. Particulars of available prints and lantern slides may be obtained by personal application at the entrances or by letter addressed "The Secretary, The Science Museum, South Kensington, S.W.7."

A compressed air service furnishes the power for driving such of the machines as are shown in motion, and the service is available daily from 11 a.m. (Sundays, 2.30 p.m.) till closing time. Where practicable, these objects are fitted with self-closing air valves, by means of which Visitors may start them at will. Other objects are arranged so that Visitors may work them by other means, and there are a few that can be shown in motion only by an Attendant.

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(The objects in the various sections are arranged chronologically.)

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ILLUSTRATED CATALOGUE

OF THE

COLLECTIONS

IN THE

SCIENCE MUSEUM,

SOUTH KENSINGTON.

MACHINE TOOLS.

Numerical references in the text refer not to the page but to the serial numbers placed at the beginning of each catalogue title. When an object is illustrated the reference to the plate of illustrations is given immediately after the title. The number at the termination of each description is that under which the object is registered in the Museum. If the object has been photographed, the Inventory number is followed by the negative number, and where a lantern slide exists, the letters L.S. are added.

In this section have been collected the various machines and appliances employed in working metal or wood into the innumerable forms required in constructive work. Such appliances frequently bear some resemblance to the earlier hand tools, but though simpler to work are invariably more complicated, the greater perfection in the machine tool taking the place of the skill and close attention otherwise required of the workman. Even with hand tools it will generally be observed that the more simple the tool the greater the skill required to obtain expeditiously a good result with it.

There are two distinct features in machine tools that have each promoted the rapid development and extension which took place during the 19th century: the first is, that they do their work almost entirely by the forces of nature without animal labour, and so are practically without any limits of size or of physical endurance; steam hammers, metal-rolling or shearing machinery, and large cylinder boring machines are examples of this unlimited power and endurance. The second feature is, the speed and accuracy with which they attain any desired result, and this is due to the copying principle now to be found in all finishing tools.

Metal-working machine tools perform the desired alteration in the shape of the material either by forcing it to flow into the required form, as in forging, rolling, and stamping, or the result is obtained by cutting from a larger mass those portions that are not

required. In most work the first stage in the manufacture is accomplished by flowing and the final stage by cutting.

Casting arrangements have been included under *Metallurgical Furnaces and Appliances*, so that the remaining tools that perform their work by causing the material to flow into the required form are represented by hammers, rolls, and presses. As these tools are nearly always driven by steam power, there is hardly any limit to the size of the work that they can be constructed to accomplish. When the "Great Eastern" steamship was proposed, however, the difficulty of forging her paddle shaft was felt to be serious until Nasmyth solved it by his steam hammer; the earlier "Great Britain" only avoided this trouble by using a propeller shaft built up of boiler plates with riveted joints.

In hammering tools, the copying principle is hardly applied, but in rolling and stamping the great saving in labour and time that it effects is fully seen. Cold stamping, from sheet metal into dies, is an extension of the method that is continually increasing in importance and applicability.

In machine tools that have a cutting action, such as lathes, planing, slotting and milling machines, the full application of the copying principle is found. The earlier lathes could turn circular work, but to produce a parallel cylinder depended entirely upon the skill of the turner; by such tools the most expert man could hardly prepare a parallel shaft, and in the earlier engines it will be found that considerable ingenuity has been exercised in avoiding difficulties that only arose through the absence of true machine tools. The foundation of the modern finishing tools is the slide-rest, by which the cutting tool is supported and directed mechanically, instead of by the unaided human hand. The greater command so obtained over the tool is of importance, as also is the means it affords for feeding the tool automatically, but the most valuable feature of the invention is that the care and labour originally spent in preparing the slides or guides is saved on every piece of work turned out by its aid, owing to the true lines contained in the rest being continuously copied on the work. Henry Maudslay fitted to the slide-rest a standard screw, through which, by change wheels, modified copies of this screw could at once be prepared on any work in the lathe. The introduction of the slide-rest was followed by the construction of self-acting tools in which the feeding of the tool into or along the work was performed entirely by the machine, so that, when once adjusted, the attention required from the workman was immensely reduced, while the speed and uniformity of the work turned out was greatly augmented. Further progress in this direction was made by the introduction of the turret lathe, and this has been followed by the development of the entirely automatic lathe, which produces, in large quantities, articles such as bolts and screws from the solid bar.

For the production of accurate machine tools the use of true planes is absolutely necessary; it was in 1840 that Sir Joseph Whitworth published his method of preparing such surfaces and for many years subsequently developed the subject, particularly as regards their application to machine tool production. A tool guided by two planes inclined together describes a straight line, and in all our lathes, boring mills, planing, slotting, drilling, and shaping machines, such lines and planes are simply being copied on to the work in progress. With true planes, an accurately divided circle, and a correct screw of any pitch, perfect machines for rapidly finishing

every description of mechanical work can, by the application of the copying principle, be constructed.

Drills and lathes are machine tools of great antiquity, but they remained very small and imperfect appliances until the introduction of the steam engine at the close of the 18th century. Then Messrs. Boulton & Watt, with their assistants, commenced the construction of large and heavy tools for engine-building, and from that time the growth of machine tools has been continuous. Planing machines (*see* Nos. 88–93) are a much later development, and were followed by the shaping and slotting machines. Milling machines, in which a large number of cutting edges are continuously at work, like the teeth of a circular saw, are not of modern invention, although it is only during recent years that this type of machine has come into such extensive use. The great advantages of such machines are that, owing to the brief interval during which each edge is continuously cutting, the speed can be high without undue heating, and that very irregular shapes can be machined by their aid. The difficulty in sharpening such cutters has also been removed by the introduction of special tools for this work. Grindstones and emery wheels in their action are milling appliances, which, although slow cutters, have the great advantages of being able to act on hardened work and of being self-sharpening.

In addition to the abstract copying that takes place in all machine tools the copying principle has been greatly extended by the introduction of machines in which an irregular pattern or template is used to control the action of the cutters (*see* Nos. 42–44, 129 and 144–5).

Wood-working Machines.—These tools are almost entirely of the cutting class, and closely resemble the corresponding machines for metal work; owing, however, to the small resistance of the material to severance the work done by the cutting edges is so light that the heat generated does not, as in the case of iron-working, impose a limit of speed on the cutter. Smooth cutting at a slow speed is, however, difficult, and appears to be only possible in all directions when the cutting edge is much guarded, as in a carpenter's plane or spokeshave, in which tools the guard is supporting the fibres. At a high speed such guarding is not required, probably because the cutting speed exceeds the splitting velocity. Owing to the soft and varying nature of the material, wood-working does not require the same degree of accuracy in its details as in the case of metal work, but in the machine tools employed no inferiority is admissible, the high speeds rendering the finest workmanship necessary. Circular saws are the most expeditious of wood-cutting machines, but on account of the amount of material that they waste in sawdust are not suited for many purposes. For cutting up logs the frame saw, holding many thin blades and reciprocated vertically by a crank motion, is generally used, but the higher speeds possible with continuously running saws have led to band saws being employed also on this work.

Wood-planing machines usually finish the four surfaces of a board in one pass, the two sides and the top by cutters or blades revolving at a high speed, while the lower face may be dressed in the same way and finished by a fixed blade or plane-iron secured in the table of the machine.

Copying lathes for turning non-circular forms in wood usually do their cutting by high-speed revolving cutters while the work only

slowly revolves, but in the small example in the collection (No. 144), which is of French manufacture, a single fixed cutting tool is used. For cheaply producing balusters of a square section, the method now employed is to fix a great number of them between two face plates so as to form a cage the large diameter of which leaves no appreciable curvature on the small faces of the individual bars; the whole set is then finished in four settings.

METAL-WORKING MACHINES.

STEAM AND OTHER POWER HAMMERS.

1. MODEL OF VAULOUE'S PILE-DRIVER. (Scale 1 : 24.) Woodcroft Bequest, 1903.

This early form of pile-driver was used in constructing old Westminster Bridge in 1739. The falling weight or "monkey" weighed 16 cwt. and had a fall of 20 ft.; the work was done by two or three horses, at the rate of from 100 to 150 blows per hour with an average fall of about 9 ft. An adjacent engraving shows the machine in operation.

The model, made by James Ferguson, F.R.S., represents, however, a machine that, owing to the limited floor space available, was driven by men turning a capstan instead of by horses. At the top of the capstan is a large spur wheel gearing with a pinion that is on the shaft of a heavy crossed frame which acted as a flywheel, so that when the work was thrown off by the release of the monkey the inertia of this flywheel gave a temporary resistance that prevented the men or animals from falling. Above the spur wheel is a winding drum that contains the rope connected with the monkey, and above this drum is a small fusee drum that winds in a rope attached to an independent weight working in a guide tube. When the monkey rope was to run down, the driving peg that connects the drums with the spur wheel was forced upwards, so releasing them, and under the pull of the small weight they ran back, so assisting the unwinding of the monkey rope.

The monkey works in vertical guides and is in two portions, the lower piece being a free-falling weight, while the upper portion pulls the rope down again after the fall; but the two portions can be used together when only a short fall is being given. At the top of the guides is a conical recess into which two levers at the top of the monkey enter, thereby being closed together, this causing them to release the lower portion of the monkey. The upper portion, however, in continuing its motion strikes a lever connected by a chain to the disengaging pin of the drum, which is thereby released so that the upper portion of the monkey runs down ready for the next blow; an independent lever prevents the driving pin engaging before the upper portion of the monkey has got home. It is probable that the machine generally worked on the shorter stroke without dividing the monkey. M. 1784. 20,698, L.S.

2. MODEL OF PILE-DRIVER (working). (Scale 1 : 6.) Made by Messrs. Sissons & White. Received 1893.

This represents a steam pile-driving machine patented by Mr. W. Sissons in 1862. It has a timber platform 8 ft. square, carried on four castor wheels running on the temporary metals. On this platform is a similar one capable of turning on a centre attached to the lower one; this swivelling platform or turntable carries the boiler and machinery, as well as the guides and framing, but these guides are not adjustable except for batter. The monkey is lifted by a travelling pitch chain, into which a bolt is forced by an eccentric attached to the tripping gear within the monkey. The winch and sprocket wheel are driven by a vertical steam engine, through double purchase gear with one frictional connection, but the chain barrel is a single one and chiefly used for lifting the piles into position. An overhanging sheave on the crank-shaft provides for additional hauling, for use in moving or rotating the machine. The model also shows some piles with their shoes fitted and the driving hoop at the top to prevent splitting.

The machine is about 40 ft. high, and will pitch a pile 34 ft. long on the rail level. The monkey weighs about 1 ton, and the complete machine 7 tons. The monkey usually has a fall of 6 ft., and delivers 12 blows per minute. The coal consumed is about 4 cwt. in 10 hours. M. 2546. 19,956 L.S.

3. MODEL OF PILE-DRIVER (working). (Scale 1 : 6.) Made by Messrs. Sissons & White. Received 1893. Plate I., No. 1.

This represents a steam pile-driving machine, similar to No. 2, but having a greater range. It contains improvements patented by Messrs. W. Sissons and P. P. White in 1872. The mounting shows the general arrangement of an engineering work in which a dam has been formed by sheet piling, and the foundations are being prepared by sinking other piles.

The machine consists of a trussed lower carriage travelling on temporary rails, and carrying above a pair of rails at right angles to the lower ones. On the upper rails is a square platform, which carries the framing of the machine together with the steam boiler and winding gear. The front of the framing has timber guides, in which is secured the long vertical guides that control and direct the falling weight, or monkey. At the front the timber framing is carried on hinges, and the back legs are adjustable by screws, so that the face of the guides can be set to any desired batter. By making the guides independent of the framing of the machine, the former can be lowered much below the rail level, so that foundation piles can be driven right home, as shown in the model between the two rows of sheet piling. The base of the frame is square and its carrying wheels are castors, so that the machine will travel equally well when turned through 90°. The monkey is lifted by a continuously running endless pitch chain, passing round a sprocket wheel on the winch barrel. This chain goes over a pulley at the top of the guides, and round a similar pulley at the bottom, thence over a guide wheel back to the winch. Through the monkey passes a bolt, which, by a pinion and external lever can be forced between the links of the pitch chain, so connecting the weight to the moving chain. When the desired height of drop has been reached, the bolt is withdrawn by a stop fixed to the guides, or it may be released by a hand rope, so allowing the monkey to fall. It is again raised by a pull at the hand rope, this causing the bolt to engage with the lifting chain. The long sliding guides, when raised to the correct position by the winch, are supported by the side chains at the front of the framing.

The boiler is of the vertical type, and supplies steam to a vertical double-acting engine. On the crank-shaft is a small smooth pulley which by friction drives a larger pulley on the intermediate shaft. One bearing of this shaft is carried in slides, so that by a hand lever the desired closing pressure can be obtained, or the friction wheel may be forced in the opposite direction against the stationary brake-block when engaged in lowering. The intermediate shaft, by a pinion, drives a large spur wheel keyed to the long barrel shaft, on which are two drums and the sprocket wheel for the chain, and these can be thrown in or out of gear by claw couplings. The two winding drums are of use in lifting the long guides, and also when getting the pile into position for sinking. On the platform is also a feed tank, from which the boiler is supplied by a pump driven from the crank shaft. M. 2545. 19,957, L.S.

4. MODEL OF HELVE OR TILT HAMMER (working). (Scale 1 : 12.) Received 1842.

This represents a tilt hammer intended for use as a mining stamp, but with an alteration to the handle top it resembles a type of hammer formerly used for tilting steel bars.

In the arrangement shown, an extension of the hammer shaft is lifted by a rotating four-arm cam. To increase the energy of the blow a spring beam is added; this also, by giving additional downward velocity, renders it possible for the hammer to strike at a higher speed than if it fell by gravity alone.

M. 2694.

5. MODEL OF FORGING MACHINE. (Scale 1 : 4.) Contributed by W. Ryder, Esq., 1857. Plate I., No. 3.

This is a machine patented by Mr. W. Ryder in 1841 for forging bars of iron and steel while red-hot.

A number of dies or swages of any desired form are fixed in the machine in pairs, the lower dies being fixed in the framing, with screw adjustments, while the upper ones are moved very rapidly up and down by means of eccentrics on the upper shaft, which is driven at about 600 revs. per min. The pairs of dies are generally arranged in a series of varying diameters. One of the lower dies is moved up and down in concert with the upper die, by means of a cam on a short shaft below; these two tools form cutting dies or shears. Such machines forge suitable objects with great rapidity and of almost standard dimensions; some examples of such forgings are shown. Inv. 1857–4. 19,746, L.S.

6. MODEL OF SHAW'S POWER HAMMER. Received 1919.

This is a demonstration model of a power hammer of the type in which a flexible connection is used between the tup and the driving gear. It was invented by Thomas Shaw, of Philadelphia, in 1866. Although largely adopted in America, it was not much used in this country.

The hammer is driven from an overhead crank by an adjustable telescopic connecting rod, which is connected at its lower end to the middle of a wide bow spring. The arms of the spring are joined by links and a strap which passes through the head of the hammer block. The latter works in a vertical guide immediately over the anvil block, which is held in a Vee groove in the main casting by means of a screw-operated wedge. Inv. 1919–351. S.M. 1225, L.S.

7. MODEL OF STEAM HAMMER (working). (Scale 1 : 4.) Presented by James Nasmyth, Esq., 1857. Plate I., No. 2.

This is a model of the original steam hammer invented by James Nasmyth about 1839 and patented in 1842. It consists of a base plate with a large central opening through which projects the top of the anvil, so that a blow on the anvil is not transmitted to the base plate. On the plate are secured two standards which form guides for the hammer-head or tup, and also support an overhead cylinder, the piston of which is connected with the tup by a piston rod passing through the bottom of the cylinder. Steam is admitted to this cylinder by a stop valve in the form of a slide, and then by a slide valve on the front of the cylinder, which by a hand lever can be moved so as to let steam in below the piston and so raise the heavy tup. When it is lifted to a height proportionate to the energy of the blow required, the steam is by the slide valve permitted to escape and the hammer falls upon the forging placed on the anvil. The cylinder is therefore only single-acting, but the top is closed, and a ring of holes communicating with the exhaust pipe is provided at a little distance down inside. In this way an air cushion is formed which helps to start the piston downwards when a long stroke is being taken, and also the steam below the piston is permitted to escape when the tup has been lifted as high as it can safely go. Soon after its invention the steam hammer was greatly increased in power by accelerating the fall of the tup by admitting steam above the piston in the downstroke and so changing it into the usual double-acting steam hammer.

The valve gear for regulating the number and strength of the blows is also arranged for working automatically. The slide valve of the hammer is connected with a small overhead steam cylinder, which always acts in such a way as to let steam below the hammer piston and so keep the tup up, but a tappet on the tup, when a certain height has been reached, strikes a lever which reverses the slide valve and so lets the hammer fall. This reversing lever is carried on an adjustable fulcrum so that the reversal can take place at any desired lift of the tup. After reversal a catch retains the valve in this position, but when the blow is struck a swinging arm on the face of the tup by its momentum strikes an arrangement of levers by which this catch is released, and the valve allowed to return to the position required for commencing the next lift of the hammer. In this way the whole energy of the fall is utilised before the steam is permitted to act again on the upward stroke, irrespective of the thickness of the forging under treatment.

A copy of the original sketch by James Nasmyth of his first conceptions of the steam hammer is also exhibited, together with a small oil painting by him which shows the general arrangement of a heavy forge and the way in which a forging is manipulated while under the steam hammer.

Inv. 1857–3. 21,736, L.S.

8. MODEL OF STEAM HAMMER. (Scale 1 : 16.) Made from drawings supplied by Messrs. R. G. Ross & Son, 1905.

This is a double-acting hammer of the arrangement patented in 1854 by Mr. William Rigby. The cylinder is bolted to a single standard, thus leaving room for work on three sides. The piston and rod are in one forging and the latter has flats on two sides and a dovetailed end for the attachment of the hammer face. The gland and stuffing-box are in halves and the former is of such depth as to render external guides unnecessary. The anvil block is dovetailed, like the hammer face, thus readily allowing changes to be made.

The admission of steam is controlled by a hand-worked piston valve; in addition the upstroke of the piston is automatically controlled by a tappet lever connected with the valve spindle and struck by the hammer head.

The anvil block is a separate solid casting which stands up through a hole in the sole plate; it has a broad base resting on a foundation of 15 in. sq. timbers. The sole plate is supported separately on similar timbers, with the object of lessening vibration.

The piston rod and hammer face weigh 40 cwt.; the steam pressure used is about 30 lb. per sq. in. M. 2256

9. DIAGRAM MODEL OF JOY'S STEAM HAMMER (Scale 1 : 6.) Presented by D. Joy, Esq., 1900.

This represents a double-acting hammer, patented by Mr. Joy in 1860, in which the motion of the reversing valve, hitherto performed by levers or tappets, is directly obtained by steam pressure. This is accomplished by causing the piston, when near either end of its stroke, to uncover a port or hole in the side of the cylinder, and thus allow steam from the cylinder to pass directly to the end of the valve, which is of the piston type, and thus push it into the reverse position. The valve is, moreover, made hollow, and allows the steam, after it has acted on the lower side of the piston and lifted the hammer, to pass through to the upper side to assist the downstroke, thus using the steam expansively, as in a compound engine. To regulate the stroke of the hammer there are holes or ports at various heights up the cylinder, opening into a channel in which slides a plug worked by a hand lever, so that the holes may be opened or closed, and thus an early or late admission of steam to the valve which reverses the stroke be obtained. A stopcock is provided to diminish, or close entirely, the port at the upper end of the cylinder, thus reducing the opening of the valve and thereby moderating the force of the blow. M. 3098.

10. MODEL OF STEAM HAMMER (working). (Scale 1 : 12.) Received 1906.

This represents a double-acting steam hammer with self-acting gear, made by Messrs. Davy Brothers. The cylinder is mounted on a double frame of the ordinary Nasmyth pattern and the hammer head slides between guides formed on it. Steam is admitted through a sliding regulator valve, and distributed by a piston valve having a third central piston which divides the steam chest into two parts, each with a separate steam inlet controlled by the regulator so that steam may be admitted to the underside of the piston only. The self-acting mechanism consists of a bell-crank lever, one arm of which is fitted with a swivel block working in an inclined slot formed in the face of the tup, while the other arm is connected with the piston valve spindle. The bell-crank lever is pivoted on a movable fulcrum, the raising or lowering of which varies the stroke. The hammer frame is bolted to a base plate resting on concrete piers and having a central opening through which the top of the anvil projects. The anvil block rests on a separate foundation of timber balks, bolted together, with a bed of concrete beneath it. The cylinder is 12 in. diam., and the weight of hammer head, piston, and rod is about 16 cwt. M. 3463.

11. MODEL OF STEAM HAMMER (working). (Scale 1 : 12.) Lent by Messrs. B. & S. Massey, 1892.

This model shows a form of double-acting steam hammer, intended for general smithwork. By the use of an overhanging framing the hammer is rendered accessible for work on three sides, but for the heavier types this form of framing is not adopted.

The cast-iron side frames carry the steam cylinder, and form also the guides for the hammer head, which may be of forged iron or steel. The base plate carries the frames, and through a bored hole in it passes the turned circular anvil block, which transmits the unabsorbed portion of the blow to the foundations shown below. The equilibrium working valve is of the piston type, with the steam in the middle and the exhaust at each end. A lever for working the valve by hand is carried backwards between the frames, and a swinging lever, actuated by the tup and carried on an adjustable fulcrum for varying the stroke, is arranged to move the valve automatically when rapid or regular blows are desired. Owing to the heavy shocks, the piston is forged solid with the rod, but the hammer and anvil faces are removable.

The adjacent photographs show a 15-cwt. Rigby steam hammer for heavy smithwork, and a 30-cwt. arch-frame hammer; in both cases the automatic valve gear, by which the head is prevented from being lifted too high, is clearly visible. M. 2415.

12. MODEL OF POWER HAMMER (working). (Scale 1 : 8.) Presented by Messrs. Peter Pilkington, Ltd., 1904.

In this mechanically driven hammer, the hammer-head is directly worked by an air-cylinder, in which the pressure is being successively diminished and augmented, owing to its being in communication with another cylinder in which a piston is reciprocated by the motive power. By this system of working, which was first patented in 1860 by Mr. T. G. Dawes and has since been developed by others, an elastic, rapid and adjustable blow is obtained with a self-contained machine.

The modern arrangement shown was patented in 1894 by Mr. R. M. Reay. The hammer-head is directly connected with a plunger which serves as a single-acting piston and also as its guide, while the upper end of the cylinder in which it works is in communication with another cylinder combined with the main standards and having in it a single-acting trunk piston actuated by a balanced crank on a flywheel shaft, driven by belting from line shafting or an electric motor. The hammer is stopped or its blow varied by two rotary non-return slide valves in the passage connecting the two cylinders. One valve, actuated by a hand lever, controls the passage from the air cylinder to the valve chamber; the other, which is connected with a treadle, controls the passage from the valve chamber to the hammer cylinder; at the top of the stroke the hammer piston passes over the port of this passage, so as to ensure pneumatic cushioning. When the passage is free, the motion of the hammer follows that of the air piston; the force of the blow can, however, be lessened by slightly covering the port to the hammer cylinder. If the latter be completely covered the hammer will be lifted to the top of its stroke and will remain there. If it be desired to retain the hammer in an intermediate position the ports to both cylinders must be covered when that position is reached, but if it is required to use the hammer as a vice, the port to the air cylinder must be covered and the port to the hammer cylinder uncovered. The air cylinder is provided with a safety non-return valve.

These hammers are built in sizes from 1·5 to 10 cwt., that represented being of the smallest size, which has a stroke of 8 in. and can deal with a maximum thickness of 2 in.; it gives 220 blows per min. and requires three h.p. M. 3336.

13. PORTABLE PNEUMATIC HAMMER. Lent by the International Pneumatic Tool Co., 1901.

Portable hammers, driven by compressed air and sometimes by steam, have been occasionally used in England since 1860, but their recent extensive adoption is due to the success with which the invention has been revived and commercially introduced in America. The principle of their action is that a free and comparatively heavy piston is reciprocated in a cylinder by air pressure, and strikes the head of a chisel, or similar tool, inserted into one end of the cylinder. The greater inertia of the cylinder causes its movement, under the rapid reversals, to be so much less than that of the internal hammering piston as to be quite endurable. There are two types of these portable hammers: the valveless, in which the piston itself distributes the air and gives from 10,000 to 15,000 short-stroke light blows per min.; and the valve hammer, which, with a separate distributing valve and a longer piston stroke, gives from 1,000 to 3,000 heavier blows per min. The air pressure now used is generally from 70 to 100 lbs. per sq. in., and it is stated that for general work a man with one of these hammers performs the work of two men with hand tools, while at caulking he is equal to three men.

The hammer shown by this sectioned example was patented in this country in 1899 by Mr. H. J. Kimmans, of Chicago, and is of the valve type. It is made entirely of steel, and is provided with a hollow handle through which compressed air from a flexible pipe is introduced; the supply is turned on by a throttle valve, controlled by the thumb of the operator and provided with a milled head by which the amount of its opening can be adjusted. The distributing valve, which causes the rapid reversals of the motion of the hammer piston, is of the piston type with an enlarged head, and is moved entirely by the air acting on this head. When the hammer piston is at the back of the cylinder, the valve is pushed outwards and so allows air to pass directly behind it into the cylinder, so that the piston is driven forwards till it strikes the chisel. In this position a groove round the piston places a port leading to the valve head in communication with pressure air, so that the valve moves and causes air to enter the front of the cylinder, the return stroke then taking place, at the end of which the hammer piston is ultimately stopped by an air cushion formed by its closing its exhaust port.

This size of hammer has a cylinder 1·125 in. diam. and a stroke of 3 in.; the piston weighs ·87 lb. and the whole appliance 9·5 lb. The normal speed is 2,000 blows per min. and the consumption 15 cub. ft. of free air in the same interval. M. 3208. 19,756, L.S.

FORGING PRESSES.

14. PNEUMATIC RIVETER. Lent by Messrs. De Bergue & Co., 1887.

This is a portable riveting machine, patented by Mr. J. F. Allan in 1879, for working by compressed air.

A piston, provided with a hollow piston rod or trunk, works in a cylinder, having a slide valve worked by a hand lever. A connecting-rod from the piston gives motion to the movable die through the medium of a species of toggle-joint, by which an increasing power is obtained so that the pressure upon the rivet is gradually increased, and the consumption of air in the preliminary closing is reduced; the trunk piston is returned by a little air let into the small annular chamber it leaves. The machine can be slung and moved about by a crane or other convenient means, the compressed air being conveyed to it through a flexible pipe, as in the case of hydraulic riveters. M. 1874.

15. MODEL OF HYDRAULIC FORGING PRESS. (Scale 1 : 8.) Lent by R. H. Tweddell, Esq., 1895. Plate I., No. 4.

Instead of forging by blows, it is now becoming increasingly general to work the heated metal by steady pressure. The pressure method is slower, but, where the mass of the forging is large, the unequal distribution through the work of the blow from a hammer is considered by many to produce flaws that are avoided by the uniform flow resulting from sustained pressure. Machine riveting is an application of forging by pressure, but when the size of a rivet is compared with that of a moderate forging, the extension of the system to general work is seen to involve pressures that hydraulic power can alone supply.

The model shows a complete forging press of the form patented by Messrs. R. H. Tweddell, J. Fielding, and J. Platt in 1885. The lower block, which occupies the position of an anvil, is secured to side standards built in masonry, and is stationary. The upper block, which represents the tup of a hammer, is formed as a crosshead, from which descend, through guides, two tie-bars to a similar crosshead below the anvil. A small hydraulic ram below the lower crosshead tends always to lift it, so that the tup is normally up. Three rams, acting downwards from the anvil to the lower crosshead, press the tup down when the pressure water is admitted into them; by this arrangement the forging pressure of one, two, or three rams can be exerted as required, and so pressure water be saved when on light work.

To the anvil and tup different swage blocks are cottered as shown, according to the work in hand; those now in position being suited for drawing down a round shaft. M. 2747. 19,753, L.S.

16. MODEL OF CHAIN-PRESSING MACHINE. (Scale 1 : 8.) Lent by Weldless Chains, Ltd., 1907.

Many attempts have been made to produce chains of the ordinary type which should be without weakness due to the welds, and such chains have been manufactured by cold punching from a cruciform bar, but their size was limited and the cost high. Weldless chains are now, however, being successfully made by impressing the link form upon red-hot steel bars of cruciform section, and the model represents a machine for this purpose, patented by Mr. A. G. Strathern in 1897–1904.

The machine consists of a heavy framework having four horizontal crank-shafts, one at each corner, geared together and driven by an engine. Each crank actuates a slide working in diagonal guides cast on the frame, and the slides carry at their inner ends pivoted quadrants, to which the pressing dies are attached. The dies are formed as segments of a circle with a double-bevelled edge, upon which the link forms are cut, and they each enter one of the angles of the cruciform bar. The die faces are mounted eccentrically with the pivots, so that the inward pressure causes them to rotate and press and feed forward the bar at the same time. The rolling motion of the dies is controlled by links, connected with a cam gear, which prevents the lateral movement being too rapid, and so releasing the pressure on the bar, and ensures that such motion shall only commence when the forward edges of the dies have advanced right

to the centre. When the dies have completed a stroke they are withdrawn and returned to their original position, the bar remaining stationary until they are again fed forward. The front ends of the dies are arranged to register with, and so prevent deformation of, the links already formed. The actual machine is provided with a means of adjusting the dies, and a water service is arranged to cool them after each revolution. The machine is placed close to the front of a furnace 40 ft. in length, and the bars travel through at a speed of 20 ft. per min., being sufficiently heated during their passage.

On leaving the pressing machine the chain is held rigid by thin webs of metal surrounding the links, and, when cool, is passed through other machines which remove the webs, separate the links, and finish them to the correct size and shape. The links are made with thickened ends, and the machine produces chains from 0·25 in. to 0·625 in. diam., and from 60 ft. to 90 ft. in length. Tests have shown that a weldless steel chain is twice as strong as an ordinary welded iron chain of the same size. M. 3523.

17. MODEL OF SPOKE-BENDER. (Scale 1 : 6.) Lent by William Melling, Esq. 1904.

The sector-spoked wrought-iron wheel was patented by Mr. W. Losh in 1830, before which cast-iron centres were generally used. Losh's wheels were almost exclusively used for the rolling stock of the early railways, and are still retained for wagon wheels.

The machine shown, which was introduced about 1850 by Mr. Melling, of Haigh Foundry, is for economically bending such spokes. Bars rolled or drawn down by forgings so as to leave greater thickness in the middle are bent roughly to shape whilst hot and clamped on a die block secured to the crosshead of a hydraulic ram; as the ram ascends, links pinned to it and hinged to links fixed on the framing close against the sides forming the completed outline. The wheel centre is completed by riveting or welding the adjacent spokes together, casting the nave round the inner ends in a suitable moulding box and turning up the circumference. M. 3371.

18. MACHINE FOR ROLLING WINDOW LEADING. Presented by Alexander Reynell, Esq. 1913.

This machine is designed for rolling window leading of H section from cast ingots and was in use about a century ago.

Two rollers, geared together, are placed one above the other and are carried in steel bearings in the framework of the machine. They consist of spindles with one simple annular ring upon each, and as they rotate and the ingot moves forward these rings press into the metal and form the cavities into which the glass is subsequently fitted. The metal displaced is forced outwards against forming plates at either side, which determine the thickness of metal and width of strip.

Previous to the introduction of these machines window leading was produced by casting and then forming in dies in a hand vice. The modern method of manufacture is by extrusion.

An example of the ingots used in the rolling mill is shown with the finished product and also an ingot in the mill and partly rolled. M. 4227.

ROLLING MILLS.

19. MODEL OF ROTARY SQUEEZER FOR PUDDLED BALLS. (Scale 1 : 12.) Presented by G. B. Thorneycroft, Esq.,1861.

This is a machine patented by Mr. Thorneycroft in 1843 to operate upon puddled balls in the manufacture of wrought iron, in place of the "crocodile squeezer," or the rotary machine of Brown. A large serrated roller revolves within a serrated semi-circular race or breast, in which it is eccentrically placed. The puddled ball from the puddling furnace is inserted at the widest place, viz., at the commencement of the race, and is rolled over and over between the serrated roller and the serrated casing on its way from the wide to the narrow end of the race, from which it emerges in the form of a bloom ready for the rolling mill, having had most of its cinder expressed from it in the process.

Inv. 1861-50.

20. MODEL OF FORGE TRAIN FOR MERCHANT BARS. (Scale 1 : 16.)

The model shows two pairs of rolls mounted in the usual housings, and carried in bearing chocks which, when removed, permit of the withdrawal of the rolls. The rolls are grooved for the production of merchant bars after the iron has been drawn down under the forge rolls. M. 2710.

21. MODEL OF MACHINE FOR ROLLING DISC WHEELS. (Scale 1 : 12.) Presented by the Institution of Civil Engineers, 1868.

This is a form of rolling mill for making solid disc railway wheels. A pair of conical rollers, mounted on two inclined shafts driven by bevel gearing, are forced against the disc by right and left hand screws, and cause it to revolve on its axis. The pressure so rolls out the red-hot metal as to leave it as a wheel with a thick boss and tire. Steadying rollers are provided to keep the disc true while being rolled. Inv. 1868-20.

22. MODEL OF TIRE-BENDER. (Scale 1 : 4.) Lent by Messrs. F. & T. Affleck, 1891.

This is a machine for bending a bar of iron into the form of a hoop, or for trueing up the hoop or tire after the ends have been welded together. It has three horizontal rolls, the middle one, which is driven by a four-armed handle, driving one of the side rolls by spur gear. The other side roll is carried in sliding bearings which can, by two screws, be adjusted to give the desired curvature to the bar to be bent, which passes under the central roll and over the two outer ones. To enable a welded tire to be rolled, the central roll is capable of being quickly withdrawn through its front bearing, so that the ring can be placed in position. A simple form of tire-drilling machine, with an adjustable rest, is combined with the bender. M. 2383.

23. MODEL OF TIRE-ROLLING MILL. (Scale 1 : 6.) Lent by William Melling, Esq., 1904.

Tires for the wheels of rolling stock were originally made in the same way as those for cart wheels, *i.e.*, by bending a bar, of the correct section and length, by means of three rolls and then welding it. About 1845 it had become the practice to apply powerful machinery to reducing the tire to exact section and circularity by rolling after welding. This is the method shown by the model, which represents an improved machine constructed about 1850 by Mr. Melling, of Haigh Foundry. There are two rolls, of the internal and external profile of the tire respectively, arranged vertically on a horizontal table provided with slots; the inner roll is connected by bevel gearing with a source of power and is spur-geared with the outer roll, thus only permitting screw adjustment within very narrow limits; different thicknesses of tire would be accommodated by changing the rolls. To the outer roll are geared two other rolls to give the required bending to the tire. These also have screw adjustment, and to admit of the necessary latitude for different diameters, and to drive in the right direction, an idle wheel kept in gear by links is provided. To keep down the tire on the table, a loose roller, which can be fixed in different positions on a hinged lever, is provided. To the table are bolted loose guide rolls which the tire touches when the correct diameter is attained; these are set by a trammel (not shown) centred on a pin in the middle of the table.

A modified machine is used for making weldless tires, which have become universal since the introduction of mild steel, which is suitable for this treatment. M. 3370.

24. MODEL OF TUBE ROLLING MILL. (Scale 1 : 15.) Received 1912. Plate I., No. 5.

The process carried out in this mill depends on the fact that the cohesion of the internal molecules of a homogeneous and ductile solid can be overcome and an axial cavity produced when the solid is subjected to the action of external rotating discs or rolls whose axes are inclined to one another and to that of the solid, the flow of material taking place from the interior outward in a helical direction.

For tubes, the metals which fulfil the necessary conditions are mild steel and copper free from cracks or blisters; the work done on the metal increases the tenacity of the finished product.

The credit of overcoming the practical difficulties of manufacture is due to Reinhard and Max Mannesmann of Remscheid, Prussia, who patented the machinery in 1885 and have since improved it.

In the disc type of mill two discs rotate in opposite directions with their axes parallel to one another, one being above the other in the vertical plane, while in the horizontal plane their axes are equally inclined to the axis of the billet; their inclination can be adjusted.

In the roll type of mill, which is that illustrated by the model, two rolls rotate in the same direction and their axes and that of the billet are in three intersecting planes; the angles of inclination of the rolls can be varied. The rolls are supported by bearings in the ends of screws disposed at 120 deg. to one another in a massive housing; there is also a guide plate arranged and disposed similarly to the rolls. The rolls and the guide are simultaneously adjustable for different diameters of billet through bevel wheels on the screws by means of a handwheel on the top. The angle of inclination of rolls and guides for different thicknesses of wall of the billet is adjustable by set screws on lugs on the housing.

The rolls are driven from a stand of three double helical pinions, of which the centre one is the driver. To allow of the adjustments of inclination of the rolls, the driving spindles are universal-jointed.

The billet, already centre-punched, is reheated to redness and placed in the trough. It is seized by the working faces, whether they be disc or rolls, and by them spun on its axis at a high velocity; their inclination give it the horizontal component which causes it to travel along, an operation which takes only a few seconds. In passing out from the rolls the hollow billet is forced over a screw-adjusted and removable mandrel, which smooths the interior.

About 10,000 h.p. is required to drive such a mill. M. 4006. S.M. 303, L.S.

25. SPECIMENS ILLUSTRATING SEAMLESS TUBE MANUFACTURE. Lent by the British Mannesmann Tube Co. Received 1903.

Seamless tubes may be produced by such means as extrusion, by drawing through dies, or by rolling on a mandrel a bored, punched, or drifted out billet, &c.

The specimens illustrate the Mannesmann process. Steel ingots cogged and then rolled into rounds in an ordinary reversing mill are sawn hot into suitable lengths from 3 ft. downwards (*see* sample). The billet is reheated to redness and passed through the Mannesmann mill (*see* No. 24), which renders it hollow and increases its length about 1·5 times (*see* sample).

To reduce the thickness of the walls of the hollow billet, the pilger (Ger. *Pilger* = pilgrim) mill, so called from its peculiar intermittent action, was patented in 1896 by the brothers Mannesmann, and subsequently improved. The arrangement is that of an ordinary rolling mill, but the working grooves are interrupted or gapped for a certain proportion of the circumference. The red-hot billet is placed on a parallel mandrel held in the pilger carriage which has a hand or automatic feed, and has also powerful springs to force the billet between the rolls ready for the "bite" when the gapped portion is reached at each revolution. The carriage also gives to the billet an intermittent rotatory motion. The hollow billet has now been made into a tube 10 or 12 times the original length (*see* sample portion).

To give the tube other dimensions, thickness, and finish, it is drawn hot or cold through dies; the latter requires annealing, but it gives the best product (*see* sample). M. 3278.

26. MODEL OF ROLLS FOR MARKING RODS. (Scale 1 : 6.) Presented by the Lords of the Admiralty, 1864.

This model represents a machine introduced by Sir R. Seppings in 1829 for rolling and branding the metal rods required for making ships' bolts. It consists of two equal rolls mounted in wood and iron housings, and worked by a winch handle apiece; screws are provided to regulate the distance between the rolls. There are three round passes, but the middle one is slightly corrugated, and on the top of each ridge bears the broad arrow, the impression of which is left on the metal every few inches in the length of the rods. M. 2727.

27. WIRE-STRAIGHTENING MACHINE. Received 1908.

This is a small appliance for straightening wire. It consists of a cast-iron base plate having mounted upon it five grooved pulleys or rollers, placed

alternately on each side of the wire, which is drawn between them, the smaller sizes by hand and the larger sizes by a draw bench. The end rollers are fixed in position while the intermediate ones are mounted on blocks, clamped by bolts whose heads move in transverse slots, thus giving the necessary lateral adjustment. A guide is fitted to lead the wire from the coil to the first roller. The machine straightens wire from 0·08 to 0·25 in. diam. M. 3551.

28. REVOLVING HEAD FOR STRAIGHTENING WIRE. Received 1912.

The old method of straightening considerable lengths of wire was by drawing it between inclined pins fixed in a slab, the pins being so set that they bent the wire slightly in opposite directions during its passage. Adjustable rollers superseded the fixed pins (*see* No. 27), and improved action was obtained by using two sets of rollers in series, the second set acting in a plane at right angles to the first. A revolving head, carrying adjustable dies, between which the wire passed, was introduced about 1870, and this perfected the action by operating equally all round the wire; further improvement was effected, as in the example shown, by the use of hardened and polished steel rollers, instead of dies, thus reducing the friction on the wire and the power required to drive the head.

The head consists of an open hollow spindle running in ball bearings and provided with a pulley at one end. It contains five rollers, fitted in slots cut through cylindrical pieces that pass transversely through holes in the spindle; these pieces are adjusted radially by set screws bearing on their ends. The wire is drawn through the head by a suitable gripping device.

The example shown straightens wire from 0·036 in. to 0·128 in. diam.; it is driven at about 1,500 r.p.m., and requires about 1 h.p. M. 4088.

29. ROLLER TUBE EXPANDER. Presented by P. A. Newton, Esq., 1918.

Boiler tubes of small diameter were originally secured in the tube plates by driving either iron ferrules, or an expander in the form of a conical mandrel, into their ends. Subsequently curved pieces or swages having a cylindrical external surface were placed between the mandrel and the tube, but the roller expander shown, which is now in common use, was patented by Mr. R. Dudgeon in 1866 and 1875.

The tool consists of a hollow cylindrical body having three longitudinal slots cut through it to accommodate three equally spaced rollers larger in diameter than the thickness of the body and free to move radially in the slots. A long conical mandrel passes through the body and is driven between the rollers so as to force them outwards against the tube; the mandrel is then rotated by a tommy bar and it rotates the rollers by frictional contact so that they roll round inside the tube squeezing the metal into close contact with the tube plate. The axes of the rollers are slightly skewed with respect to the axis of the mandrel and this causes the mandrel to be self-feeding when rotated; it also permits the rollers to set themselves so that they lie on the tube surface, and causes the tube to be rolled in a slightly curved form with a small enlargement on each side of the tube plate. The roller slots are bored from one end of the body and are closed by a cover plate secured by screws. A cap is fitted to the outer end of the body and this bears against the end of the tube and holds the rollers in their correct positions. The head of the mandrel is provided with tommy holes and the expander shown is for tubes about 2 in. diam.

Inv. 1918–223. S.M. 1192, L.S.

30. KENNEDY BENDING MACHINE. Presented by W. Kennedy, Esq., 1919.

This is a machine, patented by Mr. W. Kennedy in 1903–9, for bending tubes or rods of various sections, when cold, without distortion.

It consists of a cast-iron body having a screwed mandrel projecting upwards from its centre, and a stop at one point in its circumference. Rings or formers of the required radius, with their outer faces grooved to fit the tube or rod to be bent, are placed on the mandrel, and an adjustable top plate is screwed down above them. An arm, pivoted at the top of the mandrel, carries a vertical pin having upon it a grooved roller which is at the level of the former. The work is laid behind the stop and the roller is placed behind the end to be bent, the top plate being screwed down so as to prevent any flattening. The arm is then

revolved and so wraps the work round the former through whatever angle is required. For the smaller sizes the arm is revolved by a lever fitted to it, but for the heavier sections gearing is employed. The pin carrying the bending roller has a pinion on its lower end, which gears with teeth cut round the body, and is rotated by a ratchet lever on its upper end. The top plate is unscrewed by the bending lever, by means of a loose pin in the arm, which drops into holes formed in its upper surface.

The example shown will bend iron pipes up to 1 in. diam., and brass or copper pipes, unloaded, up to 1·25 in. diam. With suitable formers it will also deal with angles, channels, &c. The mandrel is 4·25 in. diam., and six rings are shown, for pipes of 0·875 in., 1 in., and 1·25 in. diam., having radii of 3 in. and 4 in. Inv. 1919–228. S.M. 1196, L.S.

WELDING MACHINES.

31. ELECTRIC WELDING MACHINE. Made by the Electric Welding Co., Ltd., 1904. Plate I., No. 6.

This is a small machine for welding wire by the process introduced by Prof. Elihu Thomson in 1886, in which the heating is performed by a powerful current of electricity sent through the proposed joint, while, at the same time, the parts are pressed together mechanically.

The pieces to be welded are prepared by having their ends made slightly convex and are then firmly held in clamps, one of which is fixed whilst the other is carried on a slide and is urged towards the fixed one by an adjustable spring provided with a controlling handle and a locking arrangement. The clamps are insulated and form the terminals of the secondary coil of a specially designed step-down transformer arranged in the base of the machine, by which an alternating current of convenient potential is converted into a low-pressure current sufficient to overcome the low resistance of the welding circuit, but of the greater volume necessary to ensure rapid heating; by this arrangement the difficulties that would be experienced in generating and distributing a current of the volume required for larger welds are entirely avoided. The low resistance of this welding circuit causes the heating to be confined almost entirely to the junction, at first through the imperfect contact and afterwards through the higher resistance of the hot metal; the convexity of the ends, moreover, causes the welding to commence at the interior, so that any scale is expelled and a good joint is obtained throughout. The controlling handle, which regulates the approach of the terminal clamps, has an adjustable sector connected with an arm operating a switch in the primary circuit of the transformer, and is so arranged that when the clamps have approached each other sufficiently, through the upsetting of the metal, to ensure a good joint, the circuit is automatically broken. Gauges are, moreover, provided to facilitate the setting of the metal in the clamps, the amount of projection from which varies with the size of the work. The secondary or welding circuit of the transformer is in the form of a single massive copper loop and partly surrounds the primary coil, which consists of many turns of copper wire; a laminated iron core, giving a closed magnetic circuit, is combined with the transformer.

Welding machines of this construction of considerable capacity are in use, but this small example, which is known as an automatic wire-welder and is only intended for small work, is suitable for dealing with iron wire from Nos. 18 to 6 I.W.G., or copper wire from 18 to 11 I.W.G.; the adjacent specimens show work done by it and the swelled form of joint produced. M. 3360. 30,899, L.S.

32. OXY-ACETYLENE WELDING BLOWPIPE. Lent by the British Oxygen Co., Ltd., 1912 and 1913.

The oxy-acetylene blowpipe is specially suitable for the fusion welding of metals on account of the high temperature obtainable, while the flame, being of a chemically reducing character, prevents the oxidation of the metal during the welding. The type of blow-pipe used, which requires the oxygen only to be supplied under pressure, was invented by Mons. E. Fouché in 1903, but the improved form shown was patented by Mr. K. S. Murray in 1910.

The blowpipe consists of a cylindrical barrel, to one end of which is attached a head carrying the valves and pipe connections, while to the other end the nozzle is fitted; the gases are led from the head to the nozzle by separate pipes within the barrel. The nozzle itself is formed as an injector in which the jet of oxygen draws the acetylene forward with the necessary velocity to prevent back-lighting, and delivers both gases properly mixed so as to burn at the end of the nozzle. The fore end of the barrel is bent at an angle, and the nozzle is

also bent and may be turned at any angle to suit the work in hand. The oxygen is supplied from a high-pressure cylinder through a reducing valve that is adjusted to give the pressure required by the blowpipe. The acetylene, which should be as pure as possible, is supplied under a pressure of about 12 in. of water through a hydraulic back pressure valve which prevents the oxygen from flowing back along the acetylene pipe. The temperature obtained with the blowpipe is about 6,000 deg. F. at the hottest part of the flame. In order to avoid internal strains in the welded metal, it is desirable to pre-heat the work and to anneal it afterwards. The strength of a welded steel plate varies from 90 per cent. to 75 per cent. of the original plate.

The blowpipe shown is suitable for welding plates 0·5 in. thick, and requires an oxygen pressure of about 21 lb. per sq. in. The speed of welding, with this size, is about 4 ft. run an hour with cold plates, but by pre-heating an increased speed can be obtained. Specimens of the work done are shown, the process being applicable chiefly to wrought or cast-iron, steel, and copper.

M. 4115–6 and 4177.

33. METAL-CUTTING BLOWPIPE AND ACCESSORIES. Lent by the British Oxygen Co., Ltd., 1912 and 1913.

This appliance, for cutting wrought iron or steel, depends for its action upon the fact that a jet of oxygen directed upon the previously heated metal ignites it and burns it away rapidly in the form of iron oxide. The process was not successfully applied, however, until 1904, when Mons. F. Jottrand invented a special blowpipe by which the metal is heated to incandescence while at the same time a separate jet of oxygen is directed on to it. The iron oxide formed is fused and blown away by the jet, leaving a clean narrow cut with uninjured edges.

The cutting blowpipe shown was patented by Mr. K. S. Murray in 1910. It consists of an injector blowpipe in which a jet of oxygen under pressure draws the acetylene or other combustible gas into the nozzle, the latter being formed as an annular passage surrounding the separate oxygen jet that performs the cutting. The nozzle is fitted at right angles to, and at the front end of the body tube of the blowpipe, while a valve-box is fitted at the rear end, and internal pipes lead the oxygen to the two jets. The valve-box is provided with separate valves controlling the combustible gas and the oxygen for heating and cutting, the latter being manipulated either by a lever or a thumbscrew. An adjustable guide is fitted to the nozzle to support it at the correct distance from the work.

The blowpipe is fitted up for use with acetylene, a hydraulic back-pressure valve being placed on the acetylene pipe to prevent the oxygen from flowing along it. The oxygen is supplied from a cylinder through a reducing valve fitted with gauges showing the high and low pressures.

The blowpipe may be used for cutting plates up to 12 in. thick, the greater thicknesses requiring a larger jet and higher oxygen pressure. For plates 1 in. thick the oxygen jet is 0·062 in. diam., the oxygen pressure 32 lb. per sq. in., the rate of cutting about 40 ft. run per hour, and the oxygen consumption 2·2 cub. ft. per ft. run. The cuts may be made in any desired direction, special appliances being used for guiding the blowpipe in straight lines or circles at a uniform speed. A specimen of oxygen cutting is shown, and a print shows a 9 in. armour plate being cut. M. 4117–8 and 4175–7.

PUNCHING AND SHEARING MACHINES.

34. PUNCHING BEAR. Made and lent by Messrs. C. A. Hunton & Co. Received December 1912.

This is a handy portable workshop tool for punching holes in metal plate.

The gap frame is of cast steel, supporting a die, facing which is a punch inserted into the end of a square-threaded steel spindle turned by a tommy. All parts are interchangeable.

The size shown is for holes 0·125 in. to 0·5 in. diam., depending on the thickness of the plate, up to a maximum of 0·25 in. The maximum distance of the centre of the hole from the edge of the plate is 1·75 in. The weight of the bear is 7·8 lb. and of the tommy, 1 lb. M. 4166.

35. MODEL OF COINING PRESS. (Scale 1 : 8.) Maudslay Collection, 1900.

This represents a cutting-out press for coin blanks, and was made about 1814. The bolster is mounted on a head of a cast-iron frame and the die is

carried in a massive crosshead, with adjusting nuts, reciprocated by an eccentric on a driving shaft below. The strip of coin metal is fed in by rolls, geared together and intermittently turned by a ratchet driven by a pin on the driving shaft. M. 3124.

36. MODEL OF SHEARING MACHINE. (Scale 1 : 12.) Presented by G. B. Thorneycroft, Esq., 1861.

This represents a machine patented in 1843 by Mr. Thorneycroft for shearing large iron plates. The lower blade is fixed and the upper one slides in guides formed in side standards, which hold the bearings of a strong horizontal shaft; three cams on this shaft force the blade downwards, and two light eccentrics lift it for the next stroke. The shaft has square ends, and was probably to have been driven by a cast-iron breaking shaft that would fail if the cut attempted was too heavy. The cutting edge of the moving blade is inclined, so that the cut is taken gradually across the plate and the work distributed throughout the stroke, the maximum pressure being thereby greatly reduced. Inv. 1861–52.

37. MODEL OF PUNCHING AND SHEARING MACHINE. (Scale 1 : 8.) Made by Messrs. Craig & Donald, Ltd. Received 1906.

These two machine tools are, as is usual, combined in one framing for convenience in working, to save floor space, and because of the similarity of the operations performed.

The machine is of the eccentric type; it has a massive cast-iron framing with a deep gap at each end to enable the plate to be punched or sheared at a distance from its edge. Overhanging both gaps is a main shaft of large diameter, the speed of which is reduced by spur gearing in the ratio 1 : 10·5 from that of the first motion shaft, which carries fast and loose pulleys and a flywheel for overcoming the variable resistance. Each end of the main shaft is turned down eccentrically, and on the pin thus formed is fitted a block which slides in a horizontal slot in an apron situated between adjustable V-guides; a reciprocating movement is thus impressed on the apron. To its lower face is bolted the shear blade or punch. For punching there is a stop motion, consisting of a cam interposed between the block and the apron, which can be turned by a handle. This allows of the exact adjustment of the plate under the punch, the latter coming down to the surface without being forced through. This mechanism is not required in the case of shears. An adjustable hinged forked piece between the punch and its bolster serves to strip the plate off the punch as it rises.

The punch and shears move continuously, but their working periods alternate, so as to lessen the fluctuation in energy absorbed. Simple radial post cranes, each with a trolley for conveniently slinging the heavier pieces, are incorporated with the framing. M. 3444. S.M. 348, L.S.

38. MODEL OF PUNCHING, SHEARING, AND NOTCHING MACHINE. (Scale 1 : 8.) Made by Messrs. Craig & Donald, Ltd. Received 1906. Plate II., No. 1.

This resembles the preceding (No. 37), except that a third machine tool is combined in the one framing and that the construction is of the lever type. The main shaft, whose speed is reduced by spur gearing as before, is placed at right angles to the position adopted in the eccentric type. On the main shaft are two cams for each lever, which rub on a beam suspended from the end of the lever by tie-rods. One end of the lever is centred in the framing and, for punching, the other end presses on a D-shaped punch-block, which slides in a vertical sleeve and is raised by two side levers slotted to allow the stop motion to operate; this consists of a cam interposed between the lever and the punch-block and turned down by a handle. For shearing, the outer end of the lever is inserted in the apron carrying the shear blade. A connecting block is hung in a space within the apron from an eccentric pin on the end of the shaft. The pressure is thus always exerted centrally. Another block inserted between the former one and the apron provides for the stop motion. The two blocks are slotted and can be moved back by a handle so that one enters the other to the amount of the stroke. The punch and shears have each a period of rest determined by the cams, which are so timed that their periods of operation and that of the notcher are consecutive. Jib cranes are incorporated with the framing. M. 3445. 31,773, L.S.

39. EXPANDED METAL. Presented by the New Expanded Metal Co., Ltd., 1892 and 1902.

The process and machinery for converting a sheet of metal into a trellis or network by shearing it through at intervals, and at the same time bending or stretching the partly-severed strips, was patented in 1884 by Mr. J. F. Golding, of Chicago, and subsequently improved. The work is completely performed, without the removal of any portion of the original plate, in a long shearing machine provided with suitably shaped blades, and fitted with mechanism for holding and feeding the plate.

In the original type of machine the upper and lower blades were formed of small elements, each set back from its neighbour to the left, while the sheet or strip of metal to be operated upon was fed in diagonally from one side of the stepped jaw. A photograph shows this machine, and there are three specimens relating to the trellis made by it; first the sheet of metal, then the sheet with one-half converted into trellis, and finally the piece completed. From these it will be seen that the whole diagonal line of cuts is made with one stroke of the shears, which, at the same time, bend down the strips without stretching the metal. In this way sheets of mild steel of 16 to 20 I.W.G., 9 ft. long by 7 in. wide, were converted into pieces of trellis 8 ft. long by 5 ft. wide, the reduction in length being due to the diagonal arrangement of the material after being expanded without being stretched.

In the later machine, shown in another photograph, and whose work is illustrated by a piece of 0·19-in. thick steel plate, one-half of which it has converted into trellis of 3-in. mesh and 0·375-in. strand, the lower shearing blade is straight, while the upper one is of notched outline. The sheets are fed through from the back at right angles to the blades, and the notched blade, as it descends, at first cuts a series of slits in a straight line along the edge of the plate, and then stretches the severed strands while depressing them into the mesh outline, so that the length of the sheet remains unaltered. Between each stroke the plate is moved laterally through a distance equal to half of the pitch of the corrugations, so that the slits in one row come opposite the bars in the next, and the trellis is formed with lozenge-shaped spaces. The sheets converted in this machine range from No. 24 to No. 3 I.W.G. and are 8 ft. in length, but after extension their width is from twice to twelve times what it was originally.

Owing to the stiffness and good bonding surfaces that this trellis possesses, the lighter gauges are largely used as lathing for ceilings or plaster partition walls, while the heavier kinds are employed to reinforce concrete floors and other structures by introducing steel into those portions of the concrete under tension. M. 2430.

LATHES.

40. EGYPTIAN LATHE. Received 1912.

This is an example of an Oriental form of the earliest type of lathe, which is somewhat more developed than those of India and Persia. These primitive lathes are in use at the present day.

The lathe consists of a base-board at the right-hand end of which is fixed a transverse wood block, while near the left-hand end is placed a similar block fixed to a stretcher bar which passes through a mortice in the fixed block, where it is wedged at any required position. The centres are Z-shaped iron bars with pointed ends and their tail ends are wedged in mortices cut through the blocks. A long iron bar, about 1 in. square, is laid across the two blocks, parallel with the centres, to serve as a tool rest. The work, having a centre hole at each end, is placed between the fixed centres and is rotated backwards and forwards by a bow which is peculiar in that one end of the string is wound round a hinged piece near the handle which serves to regulate the tension of the string. The tools used are the chisel and the gouge and, as shown by an adjacent photograph, the operator sits before the lathe on a slightly elevated seat with the heels on the stretcher and the toes on the rest bar. The bow is held in the right hand and the tool handle in the left, the front end of the tool being held between and guided by the toes of the right foot. Cutting is performed only when the work is turning towards the operator.

Samples of window lattice or " mushrabiyeh " work are shown, together with the wooden gauges employed, and also a drill for use in the lathe.

M. 4141. S.M. 1272, L.S.

41. POLE LATHE. Lent by Messrs. Thos. Noakes & Sons, Ltd., 1907. Plate II., No. 2.

The earliest known form of the lathe was very simple. It consisted of two fixed centres between which the work was supported, and motion was given to the work by a bow, the string of which was wrapped round it, or by a cord the ends of which were pulled by an assistant. The turner was seated upon the ground holding the tool against a rest with one hand and working the bow with the other, cutting being performed during one half of the motion when the work was revolving towards him. Such lathes are still used in the East. In Europe, however, probably owing to the erect position generally adopted by the turner, the fixed centres were placed higher and an improved method of rotating the work was employed. In this the bow was replaced by a spring beam or pole above the lathe, and a cord was fastened to the free end of it, then wrapped round the work and its lower end attached to a treadle to be worked by the foot. This method largely increased the power and left both hands free for the management of the tool. The pole lathe shown was made about 1800 and was in use by Messrs. Noakes occasionally as late as 1879 for turning such objects as the beer cock shown. Similar lathes are still used by the chairmakers of High Wycombe and Oxfordshire. The lathe bed consists of two oaken beams a few inches apart, mounted on two posts which are provided with feet for attachment to the floor. The headstocks are massive blocks of oak passing between the beams and each carrying a fixed iron centre; one head is fast and secured by a wedge, while the other is loose and may be secured by a clamping bolt in any position along the bed. The cocks to be turned are mounted on a wooden mandrel, and a wooden tool rest, shaped to suit them, is secured to the bed by a clamp. The pole consists of a straight tapered bough of a tree, and in practice it would be held at one end and supported on a cross-bar at about the middle of its length in order to provide for lateral adjustment. The driving cord is attached to the free end of the pole, passes round the mandrel, and then between the bed to the treadle below, which consists of two pieces of wood attached to the floor by leather hinges. A back rail is fitted to the lathe for the support of the operator. M. 3514. S.M. 185, L.S.

42. EARLY ORNAMENTAL LATHE. Received 1912. Plate II., No. 3.

This is a bench lathe of an early type, probably made in France about 1740. It belonged to the second Earl of Macclesfield, the famous astronomer and President of the Royal Society from 1752 until his death in 1764.

The lathe has a double iron bar bed, with heavy brass clamps for fixing to the bench. It is driven from a pulley on an overhead shaft which is carried in a block sliding in a frame fixed to the bench. A hand-driven flywheel with a leaden rim is fixed to the shaft and drives, by a round belt, a two-speed pulley on the mandrel; the belt tension is adjustable by moving the block up or down by means of a long square threaded screw.

The headstock is pivoted between the bars of the bed in blocks at either end, which are clamped to the bed by bolts and which extend upwards to carry a device for holding the headstock in a central position when it is not desired to use the lathe for turning rosettes. A small lever on each block has a slot cut in it which may be made to engage a pin projecting from the headstock.

The mandrel rotates in white metal bearings and is able to slide longitudinally, although normally held in its back position by a spring. For screw-cutting, three guide screws of different pitch are cut on the back portion of the mandrel and each screw has beneath it a short lever with a portion of threaded surface that engages the screw and traverses the mandrel when the lever is held up by a wedge. This is the earliest method adopted for screw-cutting in the lathe. The mandrel is screwed at both ends to take chucks. At the rear end rosettes are mounted, but if fitted with a faceplate and provided with a rubbing tool held in a rigid tool post fixed to the bench, the lathe may be used for copying medallions, &c. A number of rosettes are shown on the mandrel and when in use are kept pressed firmly against the rubbing tool by a serpentine spring fixed to the bench. The rubber support is adjustable in height and provided with three clamps for holding them.

The slide-rest is of the early French form in use early in the 18th century. It is adjustable for height by a vertical screw and may be firmly clamped at the desired level by a single bolt which passes through the body of the rest and through slots in the movable portion. Screw traverse in one direction is provided and also a slide at right angles on which the tool is carried. A screw

passing through the moving part of this slide abuts against the fixed part so that the depth of cut may be regulated.

The chuck shown in place is an eccentric chuck in which the work is held on a nose on the sliding portion, which may be set over by hand and locked in place by tightening four screws. The nose revolves on a spindle and is held in any position by a detent engaging a divided wheel attached to the nose.

Provision is made for fitting the oval chuck, which is seen on the bench beside the lathe. It is of the English pattern, in which the movement is imparted to the slide which carries the work by pallets which pass through the back of the chuck and embrace an eccentrically mounted, fixed, circular ring. It is provided with means for taking up wear in the slides.

Various additional rosettes and chucks are shown. M. 4204. S.M. 446, L.S

43. ROSE ENGINE. Received 1872. Plate II., No. 4.

This is the bench portion of a German lathe made about 1750 for ornamental turning, but the general arrangement of the complete machine is shown in the adjacent photograph. The lathe was driven from a pulley on an overhead shaft carrying a flywheel, which received its motion from a cord connected to a treadle in the base. This shaft was supported in an adjustable bearing box, carried by a framework secured to a massive wooden cabinet with which the lathe was combined; but the whole machine was covered with a mass of rococo decoration by which the framework was concealed.

The mandrel headstock is hinged below and provided with a strong spring to keep anyone of the several cams or rosettes, which the mandrel carries, in close contact with a fixed rubber. The rocking or " chattering " motion thus imparted to the mandrel as it revolves causes a stationary cutting tool to produce on the work a wavy line or rosette instead of a true circle.

The pattern shown on the boxwood in the chuck is one generally employed for the backs of watch-cases, and is produced by using a cam with 24 similar waves; by means of a tangent-screw the cam is rotated, relatively to the work, through half a wave between consecutive cuts, and this causes the depressions of one ring on the work to correspond with the tops of the waves of its adjacent ring, and produces the appearance of spiral curves, although the design is built up entirely of concentric rings. As several different cams are provided, many designs may be obtained by suitably manipulating the tangent-screw.

Another set of cams is arranged to give end motions to the mandrel, so that a cylindrical surface can be ornamented, or lines may be cut of varying depths on face work. The headstock can, moreover, be clamped by screws, and the lathe be thus rendered suitable for ordinary turning.

The rose engine is still used for certain decorations, but in the modern machine, some specimens of work from which are shown, the cam is relatively very much larger than in this early example.

This lathe, in its original condition, was rendered automatic in its action by a mechanism bolted to the underside of the table. M. 1912. 24,699, L.S.

44. ROSE ENGINE AND ACCESSORIES (working). Received 1910.

The art of rose-turning, or producing waved lines in the lathe, appears to have originated about 1650, and reached the height of its popularity about the middle of the 18th century, when all kinds of articles were ornamented in this way. After a revival about 1800, the art declined, so that it is now applied only to such articles as the backs of watch-cases.

The waved lines are produced by a fixed tool while the work is oscillated by means of a rosette fitted to the lathe mandrel and held against a fixed rubber. The earliest machines were very crude; only the nose end of the mandrel was moved, and weights were employed to hold the rosettes against the rubbers. In the later and more perfect machines, such as the one shown, which was made about 1800, the whole headstock oscillates and springs are used instead of weights.

The lathe is mounted on a slotted wooden bench, having a treadle and driving pulley below. The headstock consists of a casting carrying the mandrel bearings and pivoted on two pointed screws passing through sockets fitted into slots in the bench; an arm projects downward from the headstock and is connected, by an adjustable rod, with the lower end of a flat spring screwed on to the back of the bench. The bearings are of white metal, in halves, and are parallel so that the mandrel may have a certain amount of end play when required. The mandrel has a screwed nose, on which the various chucks are fitted, and behind it is a collar to take the thrust when turning. There are 32 rosettes, with different numbers of waves, one of which is fixed to the mandrel, while the others are keyed on a loose sleeve which can be rotated, relatively to the

mandrel, by means of a tangent screw and wheel, or by hand. The tangent screw is carried by a notched division plate, portions of which are divided into different fractions of the circle, and the pawl for this is carried by the driving pulley which is fixed to the mandrel. Thus the rosettes may be set in any position on the work and successive waves may be stepped round by fractions of the pitch of the waves, as is often required.

Some of the rosettes have waves on their side faces, so that when a suitable rubber is placed against them they give a longitudinal motion to the mandrel, and thus cause the tool to cut lines of varying depth; another adjustable spring, acting on the rear end of the mandrel, holds the rosette against the rubber. The two motions may be used together.

The lathe is fitted with a slide rest in which the transverse motion is given by a screw with a divided head, while the top slide which carries the tool is moved forward by hand, the depth of cut being regulated by an adjustable stop, when ornamenting a flat surface, but by a rubber fitted close beside the point of the tool when working on a curved surface. The rest has vertical and angular adjustments, and the tool slide may be replaced by another carrying a drilling spindle, which would be rotated by a belt from an overhead gear.

When preparing work the headstock is fixed by two screws and the mandrel is rotated rapidly by the treadle, but when ornamenting, the treadle is disconnected and the mandrel is turned at a slow speed by a hand gear fixed at the front of the bench.

The lathe is shown fitted with an elliptic chuck similar in construction to that shown in No. 56, but provided with two additional slides, moving at right angles to one another, which enables it to be used as a compound eccentric chuck also. The nose carrying the work forms part of a movable plate with 96 notches round its edge, so that by the aid of a pawl the work can be set in certain positions as when describing a series of eccentric circles round the work.

Another accessory is a straight line chuck. This consists of a vertical bed-plate bolted to the front of the headstock, and a plate sliding in V-grooves in it which is moved up and down, by a partial rotation of the mandrel, by means of a chain wound on a pulley screwed on the mandrel nose. The sliding plate carries a notched division plate with a screwed nose, so that straight lines or waves may be cut across the work in any direction. Two other special chucks are shown, one for mounting, on a mandrel, prismatic work the faces of which are to be ornamented, and the other for mounting work with its axis at any angle with the axis of the lathe mandrel. A set of rubbers for the different rosettes and various cutting tools are exhibited, as well as specimens of the work executed. M. 3759. S.M. 222, L.S.

45. WATCHMAKERS' TURNS. Received 1910.

These are two specimens of the miniature lathe known as a "turn" or a "turnbench," upon which, for many years, the small turning required for watches and clocks was performed; since about 1870, however, they have been largely superseded by the more elaborate watchmakers' lathe seen in No. 57. The turn is held in a vice, and the work is rotated intermittently by a bow, or continuously by a handwheel and band; the bowstring or band is wrapped round a ferrule fixed on the mandrel carrying the work. One hand is used to rotate the work, while the other guides the tool.

One specimen is a dead-centre lathe consisting of an iron bar with two headstocks formed in one with it; these headstocks are bored for the reception of the centres, which are clamped in the required positions by set-screws. The middle part of the bar is slotted to accommodate a bolt that clamps the tool-rest in any position along it. Transverse and vertical adjustments are also provided for the rest.

The other specimen has two headstocks, one of which is loose and may be clamped in any position along the bar; these support a rotating mandrel, upon the projecting end of which the work is mounted. On the mandrel is a pulley for driving with the bow, and an adjustable tool-rest is fitted. M. 3760.

46. MACHINE FOR ORIGINATING SCREWS. Maudslay Collection, 1900.

This appliance was made by Henry Maudslay about the year 1800, for the purpose of producing screw threads of any desired pitch. He had tried to obtain an accurate thread by winding steel tape round a cylindrical bar and by other means; but the method introduced in this machine consists in the use of a chisel edge, secured at the calculated angle with the axis of the bar to be screwed

and free to travel, without turning, along the revolving bar under the action of the inclined edge. Cylinders of hard wood and soft metal were employed, and from the best of the screws thus obtained copies were produced in steel for use as standard screws, which were subsequently still further improved by various methods.

The instrument consists of a flat horizontal plate, beneath which projects a lug pierced by a cylindrical horizontal hole 1·5 in. diam., through which is passed the bar to be screwed; the bar is then placed in a lathe, the bed of which prevents the rotation of the plate while permitting it to slide longitudinally. Through the top of the whole projects downwards a concave chisel edge, carried by a holder secured to a large disc provided with a tangent screw adjustment finely graduated, so that the chisel edge can be set at the exact inclination with the axis of the cylinder corresponding with the pitch of the thread desired. Through the side of the hole enters the front of a chaser, of the same pitch, carried in a small slide-rest with screw adjustment, while the chisel edge is forced downwards into the work by a screw fixed above the graduated circle. When the cylindrical rod is rotated the inclined action of the chisel causes the screwing stock to travel along the bar, and the chaser which follows cuts the thread thus started. M. 3119. 26,314, L.S.

47. SCREW-CUTTING LATHE. Maudslay Collection, 1900. Plate II., No. 5.

This lathe was constructed at the end of the 18th century, and is believed to be the first workshop machine in which Henry Maudslay combined a leading screw and change wheels for producing screw threads.

The bed consists of two triangular bars, secured at a fixed distance apart and supported on feet by which it was secured to a bench; the height of the centres is 1·5 in. and the length of the bed about 3 ft. The headstocks are fixed to the back bar only, but the slide-rest, which is of gunmetal, slides on both bars and carries a toolholder which can be moved to or from the work in V-slides by means of a screw fitted with a graduated disc and a winch handle. Between the two guide bars is a metal leading screw 1 in. diam. by 0·25 in. pitch, cut with a square thread which is, however, exceptionally narrow. This leading screw was geared to the lathe spindle by change wheels, while a split nut and a clamping device at the bottom of the saddle formed a connection between the saddle and screw which could be released when desired. M. 3117. 26,159, L.S.

48. MAUDSLAY'S SCREW-CUTTING LATHE. Maudslay Collection, 1900.

This is a small example of the original screw-cutting apparatus invented by Henry Maudslay about the year 1800, in which, by the combination of a mechanical toolholder or slide-rest, with a power-driven screw feed, the screw-cutting lathe was produced.

The lathe is arranged for driving by hand power; the screw to be cut is carried between centres, while the leading screw is low down in the bed, and a wide saddle which carries the upper rest or toolholder is connected to it by a form of split-nut, adjustable from below, the saddle also carries an adjustable stay to prevent springing of the rod being screwed, while the depth of the cut is controlled by a handwheel with a graduated edge. The leading screw has 30 threads to the inch and on its axis is a wheel of 24 teeth which, through an intermediate wheel, gears with a wheel of 45 teeth on the lathe axis, so that the screw being cut has 16 threads to the inch. The lathe is provided with 28 change wheels with teeth varying in number from 15 to 50; the intermediate wheel has a wide face and is carried on a swinging adjustable arm so that it can connect wheels of various diameters at the fixed centres.

With the lathe is shown a collection of screwing tools, both with single cutting points and the various forms of multiple-point cutting tool or chaser, while samples of screws cut in a similar machine and having from 16 to 100 threads to the inch are shown. There are also two pairs of wide calipers used for measuring the diameter of a screwed surface, and these are provided with long ends which increase the reading in the ratio of 4 : 1.

M. 3116. 26,160, L.S.

49. SLIDE LATHE. Presented by Messrs. Beyer, Peacock & Co., Ltd., 1909. Plate II., No. 6.

This improved lathe was made by Richard Roberts in 1817; it continued in use at his works until 1854, and subsequently at the works of Messrs. Beyer, Peacock & Co., until it was presented to this Museum. One of its features is

the self-acting saddle which slides directly upon the lathe bed, and is thus able to traverse its whole length. The ordinary slide-rest of the period was a self-contained appliance, clamped to the bed where required, and only able, without being reset, to turn work of the length commanded by its short screw. Another feature is the compact form of back gear, giving increased range of speed, which has since become general, and was probably originated by Roberts.

The lathe bed consists of three vertical members strongly braced by cross webs, and with legs bolted to it at the ends; the upper edges of two of the members form guides for the headstocks, the rear one being an inverted V, and the other, which is directly beneath the lathe centres, being a narrow flat face. The saddle is carried, at the front, entirely by the third member, which has bevelled and faced top and bottom edges. The fast headstock has a mandrel with parallel bearings, and the thrust is taken by a flat-nosed tail screw. A spur wheel is keyed to the mandrel near the front bearing, and a four-speed cone pulley, with a spur pinion at its rear end, is mounted loosely behind it; these are connected together for direct driving, or left separate when using the low gear. A countershaft is placed at the back of the headstock, and carries a spur wheel and pinion gearing with those on the pulley and mandrel; its bearings are supported in horizontal slides, which are actuated by two cam levers connected by a handle bar, so that it may be easily put into or out of gear. The saddle is traversed by a long screw carried in bearings at the front of the bed, and driven from the mandrel through a variable speed gear and a bevel wheel reversing and disengaging gear. It is fitted with a long solid nut embracing the screw, and geared to a winch handle, the rotation of which moves it along the bed; when, however, the handle is prevented from rotating by a pawl and toothed wheel attached to it, the rotation of the screw will give motion to the saddle. The feed gear consists of a flat plate wheel, with its axis normal to the mandrel, having seven circles of pin teeth projecting from its upper face which engage with the teeth of a sliding pinion mounted upon the tail of the mandrel. The plate is mounted on the top of an inclined shaft, and is held in contact by a spring, so that a change of speed is easily effected by pressing it down and sliding the pinion along until it gears with the correct circle of teeth; the pinion has a rim, engaging with annular grooves on the plate, to keep it in position. The inclined shaft is geared down by spur wheels and a countershaft, and drives, by a bevel pinion, two bevel wheels mounted loosely on the leading screw, either of which may be connected with it by a clutch actuated by levers and a rod running the whole length of the bed, and passing through the saddle; a stop placed upon this rod will cause the saddle to disengage the clutch when it reaches the end of its traverse. The saddle is provided with a transverse slide carrying a hollow vertical pillar, in which the stem of the toolholder is clamped. The loose headstock is mounted on a separate base which fits the lathe bed, in order to provide for lateral adjustment of the centre. It has an internally screwed barrel the screw of which is held by an external bridge supported on two pillars; a clamping screw is provided.

The lathe centres are 9·5 inches high, and will take work 6 feet long between them. M. 3689. S.M. 198–9, L.S.

50. LATHE AND APPLIANCES. Presented by Maj.-Gen. H. P. Babbage, 1906.

This lathe was formerly used by Charles Babbage, F.R.S., in his experimental work. It was so constructed that practically all machine shop operations could be done by its aid at a time when separate machine tools had not been developed.

The lathe bed is of cast iron and is fixed to wooden supports. The mandrel, whose height from the bed is 6·5 in., has a single pulley driven by a belt from a step pulley on a flywheel actuated by a treadle; the headstock is moved along the bed to bring the pulley in line with the desired step, and to allow of this the belt has a buckle connection. The pulley has a division plate of 200, 180, 112, and 12 holes, with a plain index. The compound slide-rest was made in 1823–4 by Joseph Clement, and was the second of its kind. It has three slides; the lowest, of shallow depth, can be clamped in any position transverse to the bed. To this is bolted a slide, with a leading screw of 9 V-threads to the inch, capable of rotary adjustment through about 45 deg.; the topmost slide is traversed by this screw and has alternative positions for the toolholder. One holder is shown in an adjoining case, while another, on the slide-rest, is fitted with a machine vice whose position can be adjusted vertically by a screw, and it is also capable of partial rotation, being divided on the edge for that purpose. To this vice can be clamped any piece of work to be machined by a milling cutter, boring-head, or bar, between centres, or held in a chuck.

A slotted bracket, fixed in alternative positions on the lowest slide of the rest, is provided for attaching work which is to be shaped, planed, or slotted. To give the desired quick traverse to the tool slide, the rack shown in the case is attached at the inside.

When it is desired to use the lathe for screw-cutting, a chuck with one of the toothed wheels keyed on it is put on the mandrel. In gear with it is a train, according to the pitch desired, held on the quadrant bolted to the lathe bed, and ending in a wheel keyed on the end of the leading screw of the slide-rest.

The appliances, made between 1824 and 1830, include the change wheels used for screw-cutting and a number of face-plates and other chucks for wood and iron; among the latter is a two-jaw chuck, self-centring by means of a right and a left handed screw. The self-centring wire chuck was contrived by Mr. S. Mordan for use in making his pencil cases, patented in 1822, and is the precursor of many modern drill chucks. Two hardened steel jaws slide in a dovetailed diametrical groove. The outside edges are turned conical and the jaws are forced together by a muff, with a corresponding interior screwed over them. In the independent three-jaw chuck for small work, the jaws are each adjusted by a set screw. There is also a chuck for cutting discs or washers. The cutter is held by a set screw in a dovetailed slide which is adjustable diametrically. The boss projecting in the centre is removable and acts as a guide by entering a hole already made. One of the later tools designed by Mr. Babbage is the adjustable face-milling cutter. This is a face chuck provided on the circumference with grooves to hold eight steel cutters held by wedges which are tightened up by tail screws. The cutters were ground on one face and one end in a special holder; they were set for diameter by bottoming in their grooves and for projection by a distance piece. This tool was extensively used in facing and ending all kinds of rectilinear work fixed to the slide-rest.

The turning tools for wood are made of short pieces of steel which are held at the cutting angle in the cranked end of a holder by means of a strap, tightened by screwing up a wedge. For iron turning tools, similar cutters are held at angles of 45 deg. in a slotted bolt or in a saw-cut pinched by a screw. It is believed that Mr. Babbage was the inventor of this now common and convenient arrangement. M. 1461. 20,520, L.S.

51. MODEL OF SEGMENTAL LATHE. (Scale 1 : 12.) Presented by Messrs. Bullivant & Co., 1891.

This represents a machine, probably constructed about 1830, for turning cylindrical portions of objects in which complete revolution was either unnecessary or impossible; such tools have been used for machining crank arms and valve gear links.

At the top of two tall standards, which are extensions of the fast headstock of a lathe, is a speed cone and flywheel, driving, by reducing gear, an overhanging crank arm of adjustable throw. A connecting rod from the crank works a rack sliding in vertical guides and gearing into a spur wheel secured to the headstock mandrel so that, as the crank rotates, the work in the lathe is rotated to and fro through an angle that is determined by the throw of the crank. The length of the connecting rod is also adjustable so that the portion of the work being operated upon can be quickly changed.

The lathe bed has an internal traversing screw, and carries a slide-rest, the toolholder of which is of the hinged type necessary in planing machines.

M 1654.

52. ENGRAVING OF SELF-ACTING LATHE. Contributed by Messrs. Joseph Whitworth & Co., 1857.

This shows the self-acting lathe patented by Sir Joseph Whitworth in 1835. The leading screw is placed within the bed and, in addition to its use in screw-cutting, serves as a rack when moving the saddle by hand and also gives the transverse automatic motion to the top slide. Inv. 1857–17.

53. BAR LATHE. Presented by Bryan Donkin, Esq., jun., 1890.

This lathe was made and used by the late Bryan Donkin, F.R.S. The bed is a finished triangular bar which was the usual form for small lathes before planing machines were introduced. The face of the cone pulley is drilled for use as a dividing plate; the corresponding locking pin is attached to the headstock. M. 2286. 20,521, L.S.

54. WATCHMAKERS' LATHE. Contributed by R. Bodmer, Esq., 1857.

The mandrel of this lathe carries at one end a chuck or face-plate with three dogs or clamps for holding the work, and at the other end a pinion with diagonal teeth gearing into a wheel fixed on an axis parallel to the mandrel, and provided with a handle by which the mandrel is caused to rotate. The mandrel is hollow, and is fitted with a cylindrical spindle having a conical point to centre the work by. A slide-rest is provided in front of the face-plate for operating on the work. Inv. 1857–9.

55. AUTOMATIC SCREW-MAKING MACHINE. Made by Messrs. Greenwood and Batley, Ltd. Received 1908.

This is a lathe, patented by Mr. C. W. Parker in 1879, for automatically producing screws. The screw blanks are turned from a metal rod, which is fed in through the fast headstock against stationary tools; these tools are then withdrawn and the screwing die advanced, and retired after cutting the thread; a parting tool then cuts off the screw. The heads are finished and nicked in a separate machine, but, originally, the machine was designed to perform these operations also.

The machine consists of a box-shaped bed, having at one end of it a fast headstock with a speed cone and a hollow mandrel, while at the other end is another headstock carrying the threading spindle and its mechanism. A shaft runs through the bed and upon it the cams giving the requisite motion are mounted. The front end of the speed cone forms the conical nose of the mandrel and is fitted with a spring chuck that guides the rod which is being fed. A diaphragm is fitted near the rear end, to which the tail of the mandrel is fixed, and inside the hollow cone a roller feeding device is fitted. In this there are two rollers, mounted on the ends of levers, which are acted upon by a cam ring, rotated by an external key, so as to accommodate rods of different diameters. The rollers are driven by skew-toothed wheels, that project through the diaphragm and engage with a spiral formed on the face of a loose sleeve; this sleeve is driven by a countershaft and spur gearing, from the end of the main spindle, through a toothed clutch, in the same direction as, but at a slightly less speed than, the spindle. When the rod has advanced to the correct distance, the clutch is thrown out of gear by a lever and cam; the spindle and sleeve then rotate at the same speed and the feed stops. The turning tools are mounted on a cross slide at the front, and fitted with screw adjustments; the slide is set at a slight angle so that the underside of the screwhead is made concave. The parting tool is mounted on a slide at the back, and is connected with the front slide by an adjustable rod so that one bellcrank lever, actuated by a cam and weight, moves both slides. The front slide is held in place, while turning, by a spring catch, which is first withdrawn by the cam lever before the slide can be moved.

The screwing gear consists of a hollow sliding spindle having the die fitted to its nose; this is driven from the main spindle, through a double sliding clutch and spur gearing, in the same direction as, but at a higher speed than, the screw blank. The spindle is advanced towards the blank by a lever and cam, but is left free when the die has commenced cutting; when the thread is completed, an adjustable collar on the spindle releases a catch, which allows the clutch to be pulled over by a spring, thus stopping its rotation and permitting the die to unscrew itself. Another cam withdraws the spindle so as to put the clutch in gear for the succeeding screw. The cam shaft is driven from the main spindle through a countershaft, spur and bevel gearing, and a worm and worm wheel; its rotation is stopped, while the blank is being turned, by disengaging the worm from the wheel, it being mounted on a swinging arm for this purpose. The disengagement is performed by a pin, fixed in the wheel, that raises the cam lever which holds the worm in gear against the action of a spring; the cam lever is held up by a catch and is attached to the end of a tappet rod, which is pushed back by the advancing screw blank, so releasing the catch and allowing the lever to fall and thus restarting the cam shaft.

Lubrication is supplied to the turning and screwing tools by a rotary pump, to the latter through the hollow spindle and a telescopic pipe. The machine will make screws from 0·125 in. to 0·312 in. diam., with heads of any form; it will turn out from 80 to 150 screws per hour of 0·125 in. diam., according to length. The main spindle runs at from 300 to 500 revs. per min.

M. 3563. S.M. 237, L.S.

56. LATHE AND APPLIANCES FOR ORNAMENTAL TURNING (working). Made by Messrs. Holtzapffel & Co. Received 1904. Plate II., No. 7.

This is a foot lathe for ornamental turning; the standards and treadle-driving gear have, however, been removed and the machine is shown with an oval chuck in use turning elliptical work.

The fast headstock has a parallel mandrel with long bearings, but for most classes of work the mandrel is pushed back until a cone on it thrusts against the front bearing, where it is retained in position by a long collar fitting over the back end and fixed to it. The face of the cone pulley is perforated with circles of holes to act as a division plate for setting out or spacing work. To the small end of the step pulley is attached a disc with a thick rim pierced with 72 large holes, in which pins can be inserted to limit the rotation of the mandrel by coming into contact with an adjustable stop; this is for the purpose of producing segmental ornament, the mandrel being turned through the required angle by hand or by a disconnecting tangent screw and worm wheel, which may also be used for dividing. For work between centres a poppet head or loose headstock is provided; there is also a collar plate to give circumferential support to long objects when being bored from an overhanging end.

A slide-rest is fitted having two slides in directions at right angles to each other. The lower slide with V-edges is very long and the screw is provided with a handle and micrometer wheel at one end, whilst its upper surface is graduated in inches and tenths. The slide is mounted on a swivel mounting with a lock nut and may be raised or lowered and set at any desired angle to the bed. The upper slide also has a feed screw and small micrometer wheel and a stop for ensuring constant depth of cut. The tool is held in a slot in the top slide by two vertical screws which pass through blocks held in the slot by flanges.

The oval chuck in its present form was patented in 1764 by Messrs. J. Williamson and J. Spackman, but chucks identical in principle, although slightly different in construction, were in use in 1700; the earliest turned ovals were, however, copied from a guide in a rose engine (*see* No. 42). The chuck shown consists of a back plate screwed on the mandrel nose, and having on its face a front plate carrying the work and sliding between V-guides. The front plate is controlled by means of studs passing through slots in the back plate, and having flat cross-pieces, which are in contact with the exterior of a ring projecting from a frame, secured to the face of the headstock at the level of the centres by pointed screws, and capable of horizontal adjustment to obtain any required eccentricity. The work thus receives an oscillating motion across the mandrel, which causes it to recede from the tool twice per revolution, in such a manner that a stationary tool cuts on the work in any position true ellipses, the limit being a straight line when the point of the tool is at the centre of the mandrel. These curves have a constant difference between their major and minor axes, equal to twice the eccentricity of the guide ring; the strip between any two ellipses is consequently not exactly uniform in width. A hand tool can be used on the rest, but owing to the importance of constancy of height such work is simplified by the use of a slide-rest as shown.

For cutting the short screws chiefly required for fastening together the parts of ornamental work, the mandrel is traversed and the tool held stationary. For this purpose the collar on the back end of the mandrel is replaced by one of a series of short guide screws; below this and attached to the headstock is a plate having around its edge segments cut with threads corresponding with the guide screws, and this plate is mounted on an eccentric pin, by which it can be put in and out of gear.

When screws or helices of greater length than the guide screws or of other pitches are required, the longitudinal screw of the slide-rest is connected with the mandrel by change wheels and the universally jointed shaft shown

M. 3364. 31,094, L.S.

57. WATCHMAKERS' LATHES AND ACCESSORIES. Received 1910. Plate II., No. 8.

General turning for watches and clocks was originally performed on "turns," or "turn-benches" (*see* No. 45), but since about 1870 the ordinary lathe in miniature has been developed and is now much used. The two specimens shown are similar to those made by Messrs. Lorch, Schmidt & Co., of Frankfort.

The lathe beds are formed from a round bar, with a flat on one side; headstocks, tailstocks, and tool rests are fitted on this and secured by clamping screws; the headstock has a projection below, which may be held in a vice or

in an adjustable foot screwed to the bench. One of the lathes has a fast headstock with a three-speed cone pulley, division circle, and index; while the mandrel is hollow, and chucks, arbors, &c. are held in its nose by a hollow draw-in spindle. The headstock of the other lathe has a mandrel to which a faceplate with three dogs is permanently attached; these dogs work in curved slots and may be clamped in any position so as to hold a plate eccentrically; a sliding conical point is fitted in the mandrel for centring the work, and sight holes are provided through the faceplate for observing it. The tailstocks have cylindrical barrels, in which different centres or runners may be clamped. A compound slide-rest is provided, as well as two T handrests and a roller-rest for filing. One of the tailstock runners consists of a hollow spindle with an arm at the inner end; this arm is provided with a hole in which the stems of centring and drilling plates are clamped; these plates have conical holes in which the end of the work is placed, while one has holes partly parallel, to serve as guides for the drills, which are secured in a holder sliding inside the spindle. A pivot-forming appliance also fits on this runner; it consists of a disc with a number of flats on its edge, in each of which is formed a longitudinal groove. The end of the pivot is laid in one of the grooves, the other end being driven, and filed down until it sinks into the correct groove, the flat face acting as a guide to the file. Behind each groove is a centre dot, by means of which a centre pin, passed through the hollow runner, sets the disc correctly. Another runner with a tapered hole serves to hold any of the sinking cutters, drill holders, or plates shown; there is also one with a sliding drill holder operated by a lever. A set of small drills from 0·1 mm. to 1·2 mm. is included. When turning work between centres, an arbor with a driver plate and an adjustable arm for the carrier pin is fitted to the headstock; for lighter work small carrier pulleys revolving on dead centres are fitted to either head or tail stock; a set of 10 small carriers of the ordinary shape, but of very small size, is provided. A large number of pointed arbors, with pulleys fixed on them, are used for mounting work between dead centres. For supporting work on the headstock an independent four-jaw chuck is used, and also an eight-screw bell-chuck, a set of 20 split chucks from 0·4 mm. to 5 mm. diam., a set of 5 split step chucks for barrels, &c., and a set of chucks to which to cement the work. There are arbors for carrying circular saws, emery wheels and wooden chucks.

A set of chucks for polishing screw heads is included. Brass split chucks hold the screws while their heads are being polished, and lantern chucks hold them by the heads when polishing the points.

Other accessories are a universal cutting frame (*see* No. 69), with guide pulleys, and an eccentric cutting frame. The latter consists of a square bar held in the slide-rest and with a spindle running through the centre of it; the spindle has a pulley on the rear end and a T-head at the front; the head has a slot in it, and along this slides a toolholder the position of which is adjusted by a screw. By this appliance circles of varying eccentricity may be described on the surface of a piece of work.

The height of the lathe centres is 1·6 in. and the beds are 8 in. and 12 in. long respectively. M. 3761. S.M. 235, L.S.

58. LATHE WITH COMPOUND HARMONIC SLIDE-REST.

Presented by the Exors. of H. C. Robinson, Esq., 1911.

This is an apparatus for producing turned solids the outlines of which are the curves, known as Lissajou's, formed by the combination of two simple harmonic motions at right angles to one another. In it the cutting tool is given the combined motion and so cuts the curves directly on the revolving work.

The work is mounted on an ordinary ornamental lathe headstock, and a bracket carrying the tool driving gear is bolted to the left-hand end of the bed. On the bracket a short transverse shaft is mounted, the front end of which has a crank, with a pin, adjustable radially from 0 to 2·5 in. The crank pin engages with a hole in a block that slides in a vertical slot formed in a gunmetal frame; this frame is bolted to a long horizontal steel bar which is supported by rollers on the bracket, and is thus moved backwards and forwards with a simple harmonic motion as the crank revolves. The crank shaft is driven through bevel gearing from a longitudinal shaft at the same level, and this shaft is driven from an upper one by spur gearing; the ratio of the speeds of these two shafts can be varied by using wheels of different sizes and an intermediate wheel fitted to a quadrant mounted on the upper shaft. The upper shaft has a square hole through its centre, and it is driven by hand by means of a disengaging worm and worm-wheel.

A compound slide-rest is fitted to the bed in front of the work, and the saddle s detached from the leading screw nut so that it can slide independently, but

it can be quickly attached to the nut by a pin, when it is desired to turn parallel portions of the work. The toolholder slides in transverse guides on the saddle, and has a vertical slot and block adjustably attached to it, with which engages a crank pin fitted to a short shaft mounted in bearings on the saddle. This shaft is driven by a universally-jointed square shaft which passes through the square hole of the upper shaft on the left-hand bracket, so that the toolholder is caused to move transversely with a simple harmonic motion at the same time that the saddle itself is moved by being clamped to the long bar driven by the main crank. The transverse crank is adjustable in length, and it can be clamped in any angular position relative to its driving shaft, and thus to the main crank. The tool can be set to the required depth by a screw and stop. The two harmonic motions may thus be of any relative amplitude, speed, and phase.

The outline of the work is formed by one half a double-looped curve, and to produce it the main crank must be turned backwards and forwards over one half of its circle only. Th example shown in the lathe is formed of two motions having amplitudes of 3 in. and 0·5 in., a speed ratio of 1 : 2, and a phase angle of 60 deg. Other specimens are shown made with different speed ratios and angles. M. 3986–7. S.M. 845–6, L.S.

59. HIGH PRECISION SCREW CORRECTING LATHE.
Lent by Messrs. Bryant Symons & Co., 1919.

This is a lathe designed for finishing screw gauges or other screws requiring a high degree of accuracy, and it is fitted with a pitch-correcting device patented by Mr. A. B. Symons in 1917.

The bed is a heavy box casting strengthened by transverse ribs and its upper surface is formed with a flat face at the back and an inverted V at the front; a separate flat slide, with 60 deg. undercut edges, is provided for the saddle. The work runs on dead centres, this arrangement being essential for the highest accuracy, and is driven by a catch plate revolving on the end of the fixed headstock spindle through suitable gearing from forward or reverse pulleys mounted on a countershaft behind the main spindle.

The two driving pulleys normally run idly on a hardened steel sleeve and have a double clutch mounted between them, which is keyed to the sleeve but is free to move endwise to engage either pulley. The clutch is moved by a convenient lever at the front of the headstock either by hand or by a tappet rod operated by the saddle. The catch plate has two spur wheels fastened to it behind, and the rear one gears with a spur wheel half its size fixed on the clutch sleeve. The second wheel gears with an equal wheel on the front end of the countershaft, which shaft passes through the clutch sleeve and carries the first wheel of the screw-cutting train on its outer end.

The lead screw is of Bessemer steel, of large diameter, and is cut with a 30 deg. V-thread, 16 threads per inch. It is mounted in a long bearing on the fixed headstock, special care being taken with the facing of the abutments in order to obviate periodic error. An adjustable phosphor bronze split nut is mounted on the saddle and, while being held rigidly longitudinally, it is free to turn slightly about the screw, so that errors in the pitch of the lead screw may be corrected by advancing or retarding the nut. A steel finger attached to the nut and projecting downwards engages with a slot in a correction bar, which is fixed to a bracket on the lathe bed beneath the lead screw. The contour of the slot in the correction bar is determined from accurate measurements of the pitch of screws cut in the lathe. The bar is mounted on a pivot and is capable of a small angular adjustment, so that a uniform increase or decrease in pitch may be given to a screw in order to compensate for alterations due to subsequent hardening of the screw.

The saddle has a longitudinal slide, giving lateral adjustment to the toolholder, and its screw has a divided thimble reading to 0·00025 in. A cross slide is fitted on this and is moved to and from the work by a lever and clamped by a hand nut. The depth of cut and tool adjustments are set by a micrometer screw with a head reading to 0·0001 in. and the slide is advanced up to a stop. Cutting and tool setting are observed through a magnifier mounted on the slide-rest.

The tailstock is mounted on a supplementary bed-slide, and can be set over slightly by means of a screw and locking nuts. The change gears are solid cast-iron discs, carefully cut, and the set provided enable all the usual pitches between 8 and 100 threads per inch to be cut. A screw-cutting chart is also provided. The lathe has a capacity of 2 in. diam. and 8 in. long. It carries with it a certificate of accuracy from the National Physical Laboratory.

Inv. 1919–336.

60. PRISMATIC LATHE. Lent by Messrs. Smith & Coventry, 1897.

This construction of lathe, patented in 1891 by Messrs. Dahlgren and Svensson, of Christiania, is for turning such sections as squares and hexagons. This it accomplishes by revolving the work between centres in the manner usual in turning, while using as a cutting tool a revolving cutter with several cutting points arranged in a circle and uniformly rotated. The speed of the cutter depends upon the number of facets to be produced and upon the diameter of their path; they revolve in the same direction as the work. Although the facets produced are not mathematical planes, the deviation can be reduced to an amount that is scarcely perceptible with a straight edge.

In the example shown, which is engaged in cutting hexagons, the revolving tool consists of three cutters, carried on a spindle at the back, revolving at twice the speed of the work, which is carried between headstocks mounted on a saddle by which the distances between the work and cutter axes can be altered; both headstock spindles are connected by gearing with a lower belt-driven shaft, swinging arms being introduced to carry change wheels and give a flexible connection. The headstock holding the work is moved longitudinally by a screw, thus automatically feeding the work along; this headstock also has an arrangement by which the correct setting of the work in relation to the path of the cutters can be effected.

An adjacent diagram model (working) demonstrates the action of the machine.

M. 2966. 19,620, L.S.

61. SELF-CENTRING FOUR-JAWED CHUCK. Lent by Messrs. Wellington & Co., 1887.

This lathe chuck, patented by Messrs. Clark and Wellington in U.S.A. in 1882, has four adjustable jaws, moved in and out by four radial screws. The screws are geared together by means of a ring with bevel teeth, housed within the hollow rim; this ring gears into four bevel pinions, one upon each screw spindle, so that all four screws work simultaneously when one is turned.

M. 1866.

62. SELF-CENTRING CHUCK. Presented by Charles Taylor, Esq., 1909.

This is an example of the spiral chuck patented by Messrs. C. and G. B. Taylor in 1887. The chuck consists of a casing having a hollow conical face, in which the ways for the sliding jaws are formed. Within this is a rotating part with a cone-shaped front face on which a V-threaded spiral is cut, and a back face formed as a bevel wheel with which three pinions engage. The jaws have teeth cut at the back to correspond with the spiral, so that when this is rotated by means of a wrench and the bevel pinions, the jaws are opened or closed. Two sets of jaws are provided, one stepped for general turning, and the other with long jaws for bar work.

In this construction, the gripping pressure is taken normally behind the jaws by the solid metal of the chuck, and not by the thread alone as in the ordinary scroll chuck. A finer thread can be used, giving increased gripping power and bearing surface, and the working parts can be hardened. Specimens of steel chips turned from bars held in this chuck are shown, together with models showing the difference between this construction and that of the scroll chuck. The specimen shown is 8 in. diam., and will take bars up to 2·5 in. diam., or ordinary work up to 8 in. diam. M. 3684.

63. MAGNETIC CHUCK. Lent by H. M. Budgett, Esq., 1912.

This form of chuck, which is essentially a revolving electro-magnet, is very useful for holding washers, rings or other articles otherwise difficult to chuck; it allows the work to be finished at one setting, and is especially valuable for grinding operations.

The chuck consists of a cylindrical chamber, with a central core in one with it, round which the magnetising coil is wound; this is tapped at the rear to screw on to the mandrel nose. A faceplate, with its centre cut out so as to form five large teeth pointing to the centre, is screwed to the outer shell of the chuck, and forms one pole piece, while a star-shaped plate, screwed to the end of the core, forms the other pole piece. The two pole pieces fit into one another, leaving a small gap between them all round, and this gap is filled up with a non-magnetic metal. The ends of the coil are connected with insulated contact rings fitted

to the rear portion of the chuck, and the brushes are carried on a ball-bearing ring surrounding them. The chuck is made perfectly waterproof, so that it may be used for wet grinding. The wires from the brush ring are led, through a double pole switch, reversible for demagnetising, to a plug which may be connected with the ordinary lighting circuit. Pole pieces of various shapes are made to suit special work. The chucks are made in several sizes from 6·5 in. diam. upwards, and are wound for either 110 or 220 volts. M. 4134.

64. COMPOUND GEOMETRIC CHUCK. Received 1912.

This is a chuck used in ornamental turning for producing cycloidal curves in great variety. It was invented by Mr. J. Ibbetson about 1815, and since that date has received many detail improvements which are incorporated in the example shown. Ibbetson's invention was a development of the geometric pen, an account of which was published by J. Baptist Suadi in 1752, and the simple cycloidal chuck was known before 1815.

The geometric chuck consists of two parts, each of which produces an epicycloidal motion as the mandrel rotates. By the interposition of one motion upon the other, and with the aid of change wheels to vary these motions, an almost unlimited number of beautiful designs can be constructed. The second part of the chuck carries the work, which is moved against a fixed tool held in the slide-rest, and it is mounted on an axis carried by a slide within the first part. The first part is similarly mounted on an axis carried by a slide within the back plate of the chuck, and is rotated through a train of gear wheels terminating in a wheel at the back of the chuck, concentric with the mandrel, but held stationary by a detent. Thus, as the mandrel rotates the first and second parts acquire a relative motion depending on the precise train of wheels chosen, and may be made to trace any number of loops, each of which represents one revolution of the mandrel.

The second part of the chuck acts in a very similar manner to the first. The work is mounted on the face-plate, which rotates on an axis attached to the slide and is driven by a train of wheels through a pinion which meshes with an internal and unseen train terminating in a wheel which is fixed to the slide of the first member, and which therefore revolves with the mandrel although eccentric to it. Thus the second part also generates a cycloidal motion and produces a number of loops which are interposed on the primary loops of the first part, which in turn are interposed on the circular motion of the back plate. By means of the slides the amplitudes of the motions may be varied and a dividing wheel is fitted in each part to enable the curves to be placed in any particular position relative to one another or to the work.

Several examples of simple curves are shown drawn, on paper fixed to the face-plate, by a pencil held in the slide-rest of the lathe. M. 4067.

65. NOBLE'S EXPANDING MANDREL. Lent by the Britannia Co., 1887.

This lathe mandrel is adjustable so that it can be set to fit various diameters of bore, instead of a separate mandrel being required for each size. This is effected by means of three wedges, whose outer edges form parts of a cylinder, sliding in dovetail grooves cut on the enlarged central portion of the mandrel. The bottoms of the grooves are inclined at the same angle as the wedges, so that when a nut, which forms part of the lathe-carrier, is screwed on to one end of the mandrel, it forces the wedges along until they fit the bore of the article to be turned. The mandrel is released by screwing up a nut on a left-hand thread at the other end. The diameter of this specimen ranges from 01·625 in. to 1·875 in. M. 1851.

66. EXPANDING MANDREL. Lent by Messrs. H. B. Barlow & Co., 1892.

This mandrel, patented by Messrs. A. B. and H. B. Barlow in 1884, consists of a tapered spindle having sliding upon it three correspondingly tapered wedges, which can be pulled along by a nut screwed on the larger end of the spindle and embracing a projection formed on each wedge. The work to be turned is carried on the cylindrical external surface of these wedges, which are prevented from slipping on the spindle by three fixed keys. An annular spiral spring keeps the wedges in position when the mandrel is slacked back. The example shown is for work about 2 in. diam., and has a range of 0·05 in. diam. above or below this size, but by using the split bush shown the effective diameter is increased to 2·5 in. M. 2467.

67. CAPSTAN SLIDE-REST. Lent by Messrs. Wm. Muir & Co., Ltd., 1907.

This is an example of the capstan rest for lathes, patented by Mr. A. Muir in 1892. Ordinary tools are used and the work may be operated upon close up to the face-plate or chuck.

The capstan block is square and has a slot along each side in which four different tools may be clamped by set screws in the usual manner. This block turns on a pivot and is secured by a central clamping screw, while a spring stop in the base, engaging with grooves formed in the under side of the capstan, holds it in the correct position for each tool. M. 3486.

68. CUTTER BAR. Received 1910.

This is a form of toolholder suitable for an ornamental lathe (*see* No. 56). A square bar, clamped in the slide-rest, carries at its end an adjustable inclined head-piece secured by a screw. To the end of this head the pieces of steel forming the cutters are clamped by a strap and set screw. Two heads are provided, one for holding gouge-shaped cutters, and the other for cutters made from a square bar. Several cutters of various shapes are shown. M. 3758.

69. UNIVERSAL CUTTING-FRAME. Received 1910.

This is an appliance for the ornamental lathe (*see* No. 56) by means of which such work as fluting, drilling, &c. may be performed. A square bar, held in the slide-rest of the lathe, has its end formed as a circular flange with a graduated edge. Upon this flange a frame is mounted capable of being clamped in any position by a bolt passing through the axis of the bar; this frame carries a spindle, with its axis at right angles to that of the bar. The spindle is driven at a high speed through bevel gearing, pulleys, and a belt, from an overhead gear. Three interchangeable spindles are provided, adapted for carrying fly-cutters, drills, and milling cutters respectively. Several cutters and drills are shown. M. 3757.

70. GEARED UNIVERSAL CUTTING-FRAME. Made by J. H. Evans, Esq., 1912.

This is a form of cutting-frame by means of which the rotating tools may be set to cut at any angle with the axis of the lathe, including the horizontal and vertical positions. It is used for cutting and ornamenting cylinders or other surfaces in various ways, and also for cutting the long spirals or helices frequently used in ornamental turning.

The appliance is held in the slide-rest by a square bar through which passes a longitudinal spindle. To the front end of the spindle is fixed a bent arm that bears against a graduated collar formed on the end of the bar; a washer and screw at the rear end of the spindle serve to clamp the arm in any angular position, a pointer on the arm passing over the graduations and indicating the angle. At the end of the arm is a boss, at right angles to the spindle, and this is fitted with a hardened steel bush, conical internally. A steel spindle fits in this and projects towards the main axis, its end being fitted with a chuck for holding the cutters, which are secured in a mortice by set screws. The back end of this spindle has a spur pinion fixed to it, which gears with a spur wheel attached to the grooved driving pulleys and mounted on a fixed conical spindle. A projecting arm carries a pair of guide pulleys that lead the driving belt from the overhead gear to the driving pulleys. Mounting the cutters on the end of the spindle in this way, and gearing them up from the driving pulleys, enables them to be run at a high speed and to get close up to the work. M. 4091.

71. DRILLING SPINDLE. Made by J. H. Evans, Esq., 1912.

This is a tool for ornamental turning, by means of which various forms of flutings are cut on the work by a revolving cutter resembling a drill.

The tool consists of a square steel bar, made to fit the toolholder of the slide rest, and through this passes a spindle running in hardened steel coned collars at each end of the bar. The front end of the spindle is coned to fit one collar, while the rear end is fitted with a loose cone, fixed to a steel driving pulley, which is held on the spindle by a screw, so that it may be adjusted to take up any wear, as it is essential that the spindle shall always run without shake. The end of the spindle is bored to receive the drill shanks, which are secured by a set screw. Various forms of drills or moulding tools are used for such work as plain drilling, making beads and pyramids of various shapes, and cutting flutings. M. 4093

72. ECCENTRIC CUTTING-FRAME. Made by J. H. Evans, Esq., 1912.

This appliance is used in ornamental turning for cutting circles of different diameters and at varying distances from the centre of a piece of work which remains stationary while the cutter revolves. When used with different tool shapes, and in conjunction with an eccentric chuck, a great variety of patterns can be produced. It may be used also for shaping up the flat faces of prisms and afterwards ornamenting them.

The tool consists of a square bar that fits the toolholder of the slide-rest, and is bored longitudinally, and fitted at the ends with hardened steel coned collars. Through this is passed a steel spindle, to the front end of which is attached a right-angled slide; a steel pulley, with a cone attached, is fitted to the rear end and is secured by a screw that serves to adjust the coned bearings. The right-angled slide carries a small toolholder that is moved along it by a quadruple threaded screw with a divided head, by means of which the tool radius is set. M. 4092.

73. TOOL FOR SPHERICAL BORING. Contributed by R. Bodmer, Esq., 1857.

This is a full-sized model in wood of a tool patented by Mr. Bodmer in 1841 for boring out connecting-rod ends and similar objects to a spherical shape, so that brasses fitted in them should be able to swivel to such an extent as to adjust themselves if the crank-pin were out of line.

The object to be bored was fixed to a lathe face-plate and the tool shown carried in the slide-rest. The cutter is held on a swivel that is carried by the tool, and is slowly fed round and rotated by spur and bevel gearing as the boring proceeds. The centre of the swivel must be on the central line of the lathe if a truly spherical seat is to be produced. Inv. 1857–10.

74. ELLIPTICAL CUTTING-FRAME. Received 1912.

This is an elliptical cutting frame working on the principle of the elliptical trammel. It is adapted to fit into a slide-rest of an early pattern and was probably made about 1800.

The brass frame has V-grooves along its sides and a bearing at each end through which the driving spindle passes.

Attached to the front end of the frame in an adjustable position is a steel framework containing two slideways at right angles to one another. The drive is taken from a pulley at the rear of the spindle to a pin which moves in the first slideway through slotted links which allow free lateral movements. The pin is fixed to one part of an adjustable slide, the other part of which passes through a gunmetal block sliding in the second or vertical slideway and is fixed to a plate carrying the cutter frame. The eccentricity of the tool in the cutter-frame is adjustable by a thumb-screw, and by altering this eccentricity and the eccentricity of the sliding pin ellipses of varying sizes and proportions may be obtained. A simple example of its work is shown. M. 4066.

75. EPICYCLOIDAL CUTTING-FRAME. Received 1912.

This instrument is a development of the elliptical cutting-frame and was introduced by Mr. H. W. Pomeroy about 1870.

The cutting-frame is held in the slide-rest by a hollow square stem. Rotating on the rounded front end of the stem is a two-speed pulley, directly fixed to the plate it drives. The latter carries a radial arm, pivoted at one end near the edge of the plate and clamped at the other end by a thumb-screw which slides in a curved slot. The frame carrying the cutting tool rotates in a bearing formed in the radial arm, and is driven through a train of wheels terminating in a wheel central with the driving plate and fixed to a spindle which passes through the hollow stem. At the rear, the spindle is held by a worm engaging in a wheel to which it is attached.

Eccentricities are set on the cutter frame and radial arm by screws, and, the axis of the arm being also the axis of one wheel of the driving train, radial movement of the arm does not throw the wheels out of gear.

For cutting ellipses the gear wheels are arranged to give a relative speed of rotation in the two parts of the cutter in the ratio of 2 : 1 in opposite directions. By varying the eccentricities all manner of ellipses can be drawn, from a straight line to a circle, and by means of the worm and wheel at the back they can be placed in any angular position. For the production of cycloidal curves the ratio of 2 : 1 is altered by the introduction of other wheels into the train.

Several examples, consisting of different arrangements of ellipses drawn on paper, are shown. M. 4068.

DRILLING AND BORING MACHINES.

76. WATCHMAKERS' DRILL TURNS. Received 1910.

These are two specimens of drilling machines used by watch and clockmakers and driven by small bows.

One has a forked frame, with a lug at the bottom for holding it in the vice; one end of the fork is tapped to receive an adjustable back centre and the other has a plain hole through it. The spindle has a shouldered fore-end fitting the hole, while the back centre holds the shoulder up against the bearing. The nose of the spindle is bored for the reception of the drills, and it carries a pulley at its rear end for the bow string to act upon.

The other specimen has a solid brass head with a plain bearing hole in which the spindle runs. The back end of the spindle carries the driving pulley, and the front end is formed as a split chuck for holding the drills. The spindle is held in position by a pin which engages with a groove in it.

A bow for use with these turns is also shown; it is of whalebone and has a fine gut band. M. 3762.

77. WESTON'S RATCHET BRACE. Lent by Messrs. Nettlefolds, Ltd., 1888.

This is an example of a ratchet brace, patented by Mr. T. A. Weston in 1866, for working drills for metals. It differs slightly from those in common use in having larger and stronger ratchet teeth. Two ratchet wheels are employed, placed with the teeth of one in advance of the other, so that the two pawls may act alternatively on them. By this arrangement the use of very fine pitched ratchet teeth is avoided. M. 1945.

78. DRILLING MACHINE. Formerly the property of James Nasmyth. Received 1899. Plate III., No. 3.

This small machine resembles the large power drills constructed by Messrs. Nasmyth and Gaskell about 1840; at that time they were, however, also constructing machines with the spindle overhanging, as now almost universally arranged.

The framing shown consists of a base with two columns supporting a cross girder which carries the drill spindle and its driving and feeding arrangements. The power is transmitted through mitre wheels to the drill spindle, which is fed downwards by a central screw supported by a crosshead carried on two small wrought-iron columns. This screw is fitted with a winch handle for feeding it downwards by hand; there is also an automatic feed given by a vertical shaft that is intermittently rotated by a pawl worked by an eccentric on the lower end of the spindle sleeve. In the larger machines step driving pulleys were used, also an independent worktable, with horizontal screw adjustment in two directions. M. 3065. 20,641, L.S.

79. ENGRAVING OF WHITWORTH'S SELF-ACTING DRILLING MACHINE. Contributed by Messrs. Joseph Whitworth & Co., 1857.

This shows a drilling machine fitted with the self-acting feed motion patented by Sir Joseph Whitworth in 1837.

The spindle is driven by bevel gearing in the usual manner; it has a screw thread cut on its upper part which gears with two worm wheels mounted on and keyed to transverse shafts. To the outer ends of the shafts friction rollers are fixed, fitted with brake blocks which are drawn together by a rod with right and left hand screw threads. When the drill spindle revolves the worm wheels are rotated by the screw, but when the rollers are gripped by the brake blocks the worm wheels are retarded and caused to act as a nut, by means of which the spindle is advanced. A handwheel on one of the transverse shafts is provided for rapidly withdrawing the drill, which it does by using the screw as a rack.

Inv. 1857–18.

80. DRILLING MACHINE FOR WATCH PLATES. Contributed by R. Roberts, Esq., 1860.

This machine, patented by Mr. Roberts in 1848 as a "normal" drill, is an arrangement for drilling a large number of holes in the frameplates of clocks and watches, to a standard template as regards position.

The drill spindle is carried on a rigid bar and on this bar also is a frame that carries the guide-pin, or stop. Parallel to the fixed bar is a similar bar, supported on trunnions and provided with a counterbalance weight; on this bar are clamped two headstocks, connected together by an intermediate spur-wheel. The headstock nearest the trunnion carries a chuck that holds the frame that is to be drilled, while the outer headstock carries a plate that has been drilled with uniform holes into which the guide pin will fit. This template is an enlarged pattern of the frame to be drilled, the ratio of enlargement being determined by the position of the two chucks on the swinging bar, which is graduated for their correct adjustment. When holes of different diameters have to be drilled the drill only is changed. On one of the templates shown the pitch circles of the train to be drilled for are visible. Inv. 1860–45. 19,742, L.S.

81. MODEL OF MULTIPLE DRILLING MACHINE (full size). Presented by Andrew Shanks, Esq., 1864.

This machine was patented by Mr. Shanks in 1861 as a means of drilling simultaneously a large number of holes close together, as in condenser tube-plates. The difficulty in such machines is to get the driving mechanism for each spindle within the restricted space between the centres, while retaining the power of altering the pitch.

In the arrangement shown each spindle has at its upper end an overhanging crank, which is also somewhat bent so that it clears the adjacent cranks. All of the crank-pins fit into holes in a connecting plate, which is moved in a circular path by a similar crank arranged above it and driven by power. In the patent specification arrangements are shown for altering the positions of the holes. Inv. 1864–46. S.M. 582, L.S.

82. MODEL OF SLOT-DRILLING MACHINE. (Scale 1 : 4.) Presented by the Institution of Civil Engineers, 1868.

This machine, patented in 1855 by T. B. Sharp and R. Furnival, is for cutting elongated holes by means of a revolving tool, somewhat resembling a drill, slowly travelling to and fro over the length of the required slot.

The machine has a box bed, supported on standards, with an adjustable table projecting in front to carry the work, which remains stationary during the operation. The overhanging drill headstock slides along the top of the bed and the rotary motion is transmitted to the tool by gearing from a longitudinal feather shaft driven at one end. The longitudinal reciprocating motion of the headstock is obtained from an adjustable horizontal crank and a connecting-rod, which drive a screwed spindle passing through a nut on the under side of the head, so that both the length and position of the slot can be adjusted. The crank motion is worked from a countershaft below the bed, driven by a belt from the upper shaft, which drives the crank by worm gear and an eccentric pinion gearing with an elliptical wheel on the crank disc; in this way the angular velocity of the crank is varied so as to render the traversing motion of the drill fairly uniform. The intermittent vertical feed motion to the drill is transmitted through a friction clutch and worm gear from a ratchet wheel actuated by a cam on the crank disc; this clutch is released when the drill is being raised or lowered by hand. A continuous vertical feed, which can be used for ordinary drilling, is provided by worm gear and another clutch driven by a belt from the upper shaft. Inv. 1868–21. 19,747, L.S.

83. ELECTRIC DRILL. Lent by the Consolidated Pneumatic Tool Co., Ltd., 1911.

This is a small portable drilling machine operated by an electric motor. The drill spindle is fitted with a three-jaw chuck, and is driven through spur gearing by the armature of a completely enclosed motor. The machine is held by a top plate and by a projecting side handle, to which the cable is attached; a switch is fitted to this handle.

The motor is wound for 220 volts, and either direct current, or alternating current of 60 cycles, or less, may be used. It takes drills up to 0·187 in. diam.
M. 3921. S.M. 494, L.S.

84. ADJUSTABLE REAMER. Lent by Messrs. Vickers, Ltd., 1912.

This is a form of adjustable reamer patented by Mr. W. J. Smith in 1910; it is intended for both roughing and finishing cuts, the blades being either of high-speed or of carbon steel.

The reamer consists of a mild steel shell, slotted and recessed to receive six blades, which are parallel on their outer edges, but inclined on their inner edges so as to fit on a hardened steel conical bolt housed within the shell. The outside of the shell is fluted between the blades, which are well backed up while having their cutting edges clear. The middle portion of the coned bolt is turned parallel, screwed and fitted with a nut that is prevented from turning by a pin in the shell. The lower and larger end of the cone is provided with two holes so that it can be rotated by a key; this action causes the cone to travel endwise, thus pushing the blades radially outwards and increasing the diameter of the reamer. The end of the cone is graduated in divisions, each of which represents a variation in diameter of 0·00025 in. The blades are cut away to clear the internal nut, and they are locked by being gripped between this nut and the shell by means of another nut threaded on the small end of the bolt. The top of the shell is recessed to receive the key of the arbor on which it is mounted. The blades can be re-ground by placing the reamer in a grinding machine.

The example shown has a maximum diameter of 1·6875 in., while its range of diameter is 0·66 in. M. 4114.

85. DRAWING OF THE BERSHAM BORING MILL, 1775. (Scale 1 : 36.) Prepared in the Museum, 1920.

This drawing, copied from the original in the Boulton & Watt Collection at Birmingham, represents the cylinder-boring mill invented by John Wilkinson in 1775, and was that on which all James Watt's steam engine cylinders were bored between 1775 and 1795. It was the first boring machine that could bore a true cylinder, and it is recorded that until Wilkinson produced such cylinders Watt was unable to make a successful steam engine.

The earliest cast-iron Newcomen engine cylinders were bored on a cannon mill by a rotating cutter head fixed on the end of an overhanging bar driven by a waterwheel or horse gear. The cylinder was fixed on a wooden carriage which ran on rails and was fed up to the cutters by a chain and winch. In such a mill the weight of the cutter head caused it to cut mainly on the lower part of the cylinder, and it received no guidance other than that given by the rough casting. A clean surface could only be formed by taking four cuts and turning the cylinder through 90 deg. after each cut, but such a surface was neither truly circular in cross-section nor straight in the bore. It served the purpose, however, of the open topped Newcomen engine cylinder, where the piston was suspended by chains; but Watt's engine, with its closed cylinder top, guided piston rod and more perfect vacuum, required the cylinder to be truly straight and circular.

Wilkinson's invention consisted in fixing the cylinder in a cradle and passing through it a long, stiff, hollow boring-bar mounted in bearings at each end. A sliding cutter head was mounted on the bar and was traversed along it by means of a long rod passing down inside the bar and connected with the head through a longitudinal slot formed along the bar. The outer end of this rod was formed as a rack and was prevented from rotating by a guided crosshead, while the feed was given by a weighted lever and a pinion gearing with the rack. The drawing shows a water wheel driving, through spur gearing, four parallel horizontal axes. On one of these axes is a large boring bar, 12 in. diam. and 15 ft. long between its bearings, while opposite to it is a smaller bar, 10 in. diam. and 14 ft. long. Both are shown with cylinders in position, held down on their cradles by chains. Adjacent to the larger bar is what appears to be a facing lathe, with a large hollow mandrel and a back centre, which may have been used for turning pistons, cylinder covers, or boring heads. Near this is a travelling carriage and hauling winch such as were used for mounting the cylinders in the old type of mill. Adjacent to the smaller boring-bar is a lathe with a long wooden bed and sliding tailstock, which was probably used for turning piston rods or the boring-bars themselves. The driving spur-gearing on this side of the mill has stepped teeth.

The drawing is entitled "Drawing of the Bersham Boring Mill by Jno. Gilpin," but bears no date. The Bersham Works were closed in 1795 and the drawing was possibly obtained by Boulton and Watt before that date as a basis on which to design a boring mill for the Soho Foundry which was under construction in 1795. The boring-bar adjacent is believed to be the larger bar shown on this drawing. Inv. 1920–97. S.M. 1116.

86. DRAWING OF A CYLINDER BORING MILL. (Scale 1 : 36.) Prepared in the Museum, 1920.

This drawing, copied from the original in the Boulton and Watt Collection at Birmingham, represents the cylinder-boring machine designed in 1795 by Peter Ewart for Boulton and Watt's new Soho Foundry, which was then under construction.

From the time that Watt started the manufacture of steam engines at old Soho in 1776, until 1795, all his cylinders were cast and bored by John Wilkinson at Bersham Ironworks (*see* No. 85). The design for a boring machine for the new works had evidently been under consideration, for James Watt, jnr., writing to Matthew Boulton on 8th June, 1795, said: "Inclosed you have Mr. Peter Ewart's plan for perpendicular boring, which I address to you as the advocate of that mode of operating. When you and my Father have come to a decision upon the subject, I shall be glad to know it, that we may immediately be proceeding with the boring-rod and other essential parts." The drawing shown is a copy of the plan referred to in this letter.

The mill had a vertical boring-bar, 12 in. diam. and 14 ft. 6 ins. long, supported by a timber framing which was housed in a masonry pit. It was rotated by a large spur-wheel at its lower end, and this was driven by an inclined shaft and bevel gearing from a horizontal shaft at the ground level. The bar was solid, with a longitudinal keyway for driving the sliding cutter head, and the feed was obtained by two rack bars attached to a loose ring on the cutter head. The racks were raised by pinions on a transverse shaft at the top of the machine, but the means for rotating this shaft is not shown. The cylinder was suspended by its upper flange from transverse timbers spanning the pit, and it was secured laterally by two sets of four struts fitted with adjusting screws.

A cylinder, 28 in. diam. and 7·25 ft. long, is shown in position on the bar, and a description of the machine is written on the drawing. Inv. 1920–98.

87. BORING-BAR. Presented by the Hydraulic Engineering Co., 1913.

This boring-bar is believed to be one of those installed at the Bersham Ironworks by John Wilkinson in 1775 (*see* No. 85). When these works were closed, in 1795, the bar was bought by Messrs. Rigby of Hawarden, from whom it was purchased by the donors about 1854.

The bar is now 11·875 in. diam. and 14·92 ft. long between the bearings, and has a central hole through it, 4 in. diam. A slot, 1·5 in. wide, extends throughout the length and passes right through to the bore. A sliding sleeve fits on the bar and on this the cutter heads were mounted. Originally the sleeve was fed along by a rack bar, as shown on the Bersham drawing, but, at some time before 1854, a central feed screw, 2·5 in. diam., was fitted, which passes through a nut bolted to a large key passing through the slot in the bar into a corresponding slot in the sleeve. The bar was also re-turned at the same time.

The screw has a right-hand square thread with two turns per inch and is carried in bearings at each end; it is secured by a collar at the driving end of the bar. At the opposite end of the bar the screw carries a loose spur-wheel with 63 teeth and having clutch dogs on its outer face, which may be engaged with corresponding dogs on a sliding handwheel keyed on the end of the screw. This wheel engages with a 60-tooth wheel mounted loosely on a fixed counter-shaft, and a 63-tooth wheel, fixed to the other, gears with a 60-tooth wheel fixed on the end of the boring-bar. Thus, when the dog clutch is engaged and the loose wheel keyed to the screw, then as the bar revolves once, the screw revolves about 0·09 turn relatively backwards, thus pushing the cutter head along towards the driving end. When the clutch is disengaged, the sleeve may be traversed by the handwheel. The drive from the nut is transmitted to the sleeve by a head on the key, the latter being fixed to the sleeve by a set screw and a cotter. The nut is inserted through an enlarged part of the slot near one end.

The bar is now mounted on two cast-iron pedestals with lower brasses only, but these are probably more modern. It was driven by a large carrier keyed on its end. Inv. 1913–172.

PLANING AND SHAPING MACHINES.

88. PLANING MACHINE. Contributed by R. Roberts, Esq., 1860. Plate III., No. 1.

This machine, made by Richard Roberts in 1817, is said to be the first one made for planing metal; it is evident, from marks on the bed, that it was made

without the assistance of such an appliance. The work is secured to a table which moves to and fro on a straight bed, under a fixed tool which is capable of being traversed so that, by the two motions, plane surfaces are produced as the tool makes successive cuts. The table is provided with bolt holes for securing the work and is moved by means of chains wound on a drum rotated by hand; the guiding surfaces are a narrow flat face on one side and an inverted V on the other. The cross-slide is supported on two standards bolted to the bed, and screws are provided for adjusting its height; it has an internal screw for traversing the tool-rest, which is capable of angular adjustment and has a hand-feed motion. The tool is held by a hinged clamp. The table is 52 in. long and 11 in. wide. Inv. 1860–59. 20,695, L.S.

89. PLANING MACHINE. Made by Messrs. Joseph Whitworth & Co., 1842.

This self-acting planing machine was patented in 1835–9 by Sir Joseph Whitworth and was known in the shops as a "Jim Crow" because of its reversing toolholder.

A leading screw in the middle of the bed of the machine, driven by fast and loose pulleys and a three-bevel wheel reversing arrangement, transmits motion to the V-guided table by means of a pair of antifriction wheels on its underside, mounted on studs perpendicular to the axis of the screw, with the thread of which their rims engage. The cross-slide is supported on and is actuated by two vertical screws connected by bevel gear and shaft fed by hand. The swivelling tool box is on a screw on the cross-slide, and is fed by a pulley and ratchet actuated by a band from a rocking pulley on the same shaft as a pinion moved by a rack rod with stops on the bed. By guide pulleys the band also turns the toolholder through 180 deg. at the end of each stroke so as to cut in both directions. The bed of the machine is 4 ft. by 15 in.; the maximum height under the tool is 12 in.

An engraving of a similar machine is shown near. M. 3561. S.M. 238, L.S.

90. PLANING MACHINE. Formerly the property of James Nasmyth. Received 1899.

This small machine was built in 1857 by Messrs. J. Nasmyth & Co., but in its arrangement and detail it is almost identical with some of the larger machines made by them about 1840. At that time, however, the firm was making rack-moved planing machines with quick return motions, but, for sizes up to 3·5 ft. wide by 8 ft. travel, the gear shown was considered to give a quieter and quicker action.

The frame is a somewhat massive casting, with two V-guides with the apex uppermost, so that, although not retaining the oil so readily as the later form, they did not form receptacles for dirt. The two standards are bolted to the main framing and are connected by a cross girder which carries a central screw by which the height of the cross-slide is adjusted; the cross-slide has an internal traversing screw, for moving the tool-rest, which is capable of angular adjustment and has a hand-feed motion. The toolholder has the usual hinged box for preventing damage to the tool in the return stroke.

The table of the machine is a single casting, with slides planed on its lower surface corresponding with the fixed guides; the upper part of the table has six longitudinal T-headed grooves for receiving the bolts for securing the work. The table is moved to and fro by a mangle-wheel motion, there being two chains passing from the lower side of the table over fixed guide pulleys down to a chain wheel, round which they pass in opposite directions before being secured; the shaft of this wheel carries at one extremity a wheel with lantern pins, or teeth, into which a small pinion on the driving shaft gears. The pinion end of this shaft is carried in a sliding bearing, so that the pinion gears alternately inside and outside of the segmental lantern wheel, thus reversing the motion after a definite length of travel has been effected. The length of stroke can be permanently altered by removing from the mangle wheel some of its teeth, which are single pins secured by nuts. In the machine shown a hand-driving mechanism has been added and the loose pulley removed. The transverse travel of the tool box is automatically given by a pawl feed, receiving its motion from the lateral play of the pinion shaft. M. 3063. 20,643, L.S.

91. SPECIMENS OF CURVED PLANING. Contributed by R. Roberts, Esq., 1860.

The two bronze specimens are examples of helical planing with pitches of 11 and 37 in. respectively. They were prepared on an ordinary planing

machine, with the work held in a headstock which made a partial revolution during the travel of the table, in a way now common in rifling machines.

The other specimen is a reed moulding cut in cast iron, to a circular arc. It was done on an ordinary planing machine, on the table of which was placed a second table or sector, centred on a stud attached to the stationary bed. The sector was attached by two chains to eyes secured to the table, which by its motion caused the sector to swing horizontally; the work was secured to the sector at a distance from the stud corresponding with the radius required.

Inv. 1860–47 & 48.

92. SHAPING MACHINE. Formerly the property of James Nasmyth. Received 1899. Plate III., No. 2.

This small bench machine, for working by hand, represents an early form of shaper. The driving shaft terminates in a disc in which is a slot carrying an adjustable crank pin, by which the length of the stroke can be varied. This pin is fitted with a block capable of sliding in a vertical slot formed on a horizontal ram that carries the tool box; the ram works in adjustable V-guides, and is fitted with a vertical slide in which the tool box is fed by hand. The work-table slides on guides on the front of the main casting and is traversed by an internal screw driven by hand power, or automatically by a pawl feed motion rocked by an eccentric on the main shaft. The table is fitted with a vice, and there is also an arrangement for holding square and hexagonal nuts while being shaped.

M. 3064. 20,642, L.S.

93. WALL DIAGRAMS OF ENGINEERS' MACHINE TOOLS. Lent by Messrs. W. Hulse & Co., 1890.

These diagrams were prepared to illustrate a paper read before the Institution of Civil Engineers, by Mr. W. W. Hulse, in 1886.

Heavy Lathe.—Three views are shown of a heavy lathe of 40-in. centres. The power is transmitted from a step pulley through intermediate gearing to a spur ring formed on the back of the face-plate, and having both internal and external teeth, a considerable range of speed being obtained by the use of sliding shafts and pinions. The bed carries two independent saddles and four top rests, arranged for simultaneous working. The saddles are moved by two fixed screws, around which work nuts carried beneath the saddles and receiving their motion from a central shaft running within the bed.

Horizontal Boring Lathe.—This a break lathe, with a heavy boring bar, to which the toolholders are secured. For boring, the cutters are held in a circular head which is traversed along the bar by an internal screw. When facing has to be done, the tool is held by an arm secured to the bar, and receives a radial movement from a screw driven by a star wheel. The table, which is arranged in the gap of the lathe, can be screwed upwards or downwards by power. It has guides for longitudinal and transverse movements, so that one setting of the work is sufficient for all holes parallel in direction.

Planing Machine.—This represents the most usual form, in which the work is secured to a horizontal table which is screwed backwards and forwards by power, while the cutting tool is carried in a rest that receives the feed motion, vertical or transverse as desired.

In the machine illustrated the table slides on horizontal V-guides, and is kept down solely by gravity. The driving screw is driven through bevel wheels at one end of the machine, a shifting belt reversing the motion. There are two independent toolholders, fed by screws in the horizontal guide that carries them; this guide can slide vertically on guides formed upon the main standards. At the top of the left standard are fast and loose pulleys, by which power is transmitted for quickly raising and traversing the tool boxes when changing work; the ordinary feed movements are given by a tappet motion driven by the table.

Vertical and Horizontal Planing Machine.—In this machine the work is secured to a fixed table in front of the machine, while the tool is held in a slide that can be driven by power in a horizontal or vertical direction. This type of machine enables facing to be done on castings that are too large to pass between the standards of the ordinary planer.

The horizontal guides, two in number, are secured to three massive standards; on these guides move saddles, driven by connected screws arranged one in each guide. These saddles carry a vertical guide, upon which slides the toolholder. This toolholder is driven by a screw, arranged between the vertical guides,

and the weight of the holder is counterbalanced by a chain and weight. Power to drive these saddles to and fro on the horizontal guides, or to move the tool-rest up or down, according to the cut required, is supplied through the usual three-bevel gear reversing arrangement.

Vertical Milling Machine.—In milling, the work is done by cutting edges formed on a revolving cutter; owing to the number of edges in use the output of such a cutter is much greater than would be obtainable with a single-edged tool.

The feature of this milling machine is that the vertical spindle that carries the cutter does not increase its overhang from the front bearing as the spindle is fed downwards. This is accomplished by carrying the spindle on a square ram, adjustable in vertical guides formed on the main standard, so that when the spindle is lowered the ram goes with it. The spindle is rotated by a spur wheel secured to it, and gearing with a long vertical pinion by which the driving power is transmitted from the usual back gear irrespective of the position of the ram. The table of the machine has a circular feed motion, and two horizontal feed motions in directions at right angles. A small centrifugal pump continually projects lubricating water upon the cutter when the machine is running. M. 2351.

MILLING MACHINES.

94. MODEL OF RECIPROCATING SAW. (Scale 1 : 5.) Made by MM. Regnard Frères. Received 1892.

This is a model of a machine saw for intricate cutting in metal sheets or plates. A full-size saw blade of the description used is also shown, together with a specimen of the work produced; but several sheets are usually cut simultaneously and iron over 1 in. thick presents no difficulty. Owing to the ease with which the saw blade can be inserted the machine is adapted for work that a band saw will not perform.

The machine consists of a planed cast-iron table supported on four legs, and carrying a heavy double-armed bracket which holds the guides for the saw blade both above and below the table. Concealed in the bracket are two horizontal levers turning on central gudgeons, one above and one below the table. These levers are connected at one end by the saw blade carried in adjustable straining holders, and at the other by a vertical link. The upper lever, and through it the lower one, are reciprocated by a connecting-rod from a crank on a shaft driven by a stepped pulley at the back of the machine. The pulley is formed with a cone clutch, which is under the control of a treadle and a hand lever, for easily starting and stopping the saw from the front.

M. 2444. 19,757, L.S.

95. WHEEL-CUTTING ENGINE. Made by Manuel Gutierrez. Received 1900. Plate III., No. 4.

This machine, for cutting the wheels of clocks, is stated to have been made in Madrid in 1789.

The blank wheel having been prepared, the spaces between the teeth are cut by a disc 0·6 in. diam., with its formed edge scored by a graver so that it acts as a fine milling cutter. This cutter is fixed on a spindle rotated by spur gearing, from a hand-driven countershaft carried between centres on a frame that swings between stops, but is secured in an adjustable slide that permits of skew teeth being cut. This head is carried on a slide so that it can be set to suit the diameter of wheel required, and there is a screw feed for adjusting the depth of tooth.

The wheel blank is secured to a vertical spindle, which carries near its lower end a disc 5·9 in. diam., extensively divided on both faces, wheels of even 47, 49, 51, and 58 teeth being provided for. The upper end of this spindle runs in a conical bush, and the lower one on a cone centre. M. 3095. 21,753, L.S.

96. WHEEL-CUTTING ENGINE. Lent by the Lancashire Watch Co., 1905.

The earliest method of manufacturing clock wheels was to mark off the blank by means of a radial ruler on a pin centred in a plate divided concentrically to numbers of teeth in common use; the teeth were then filed out by hand. Robert Hooke, F.R.S., about 1670, mounted the divided plate so that it could be rotated, added an index, and applied a revolving file (*i.e.*, a milling cutter) to the edge of the blank. Various improvements took place in the succeeding century; the tool in the form shown, known as the Lancashire pattern, is due

to John Wyke (*b.* 1720, *d.* 1787) of Prescot, a seat of the watch industry from early times.

A circular plate, divided for 55, 60, 63, 64, 70, 72, 75, 80, and 100 teeth with an adjustable spring index, is mounted on a spindle in a cone bearing below and a split collar above, in a cast-iron frame on three legs; on this spindle the wheel blank to be cut is clamped, the cutter is on a spindle driven by a gut band, and mounted in a frame that can be swung out of the way while the blank is being set for a fresh tooth. The bearings of this frame can be slightly tilted so that skew teeth can be cut. The whole is adjustable by a screw in V-guides on the frame to admit of blanks of different sizes.

This machine has now practically been superseded by a tool in which a large number of wheels are cut simultaneously. M. 3422.

97. GEAR CUTTERS. Contributed by R. Bodmer, Esq., 1857.

These circular steel cutters or milling tools, patented by Mr. Bodmer in 1839 as a means for cutting the teeth of small spur wheels, racks, &c., are now in general use for the purpose of cutting gearing of all sizes. The cutters have teeth very similar to those of a saw or a file, but shaped to the profile of the spaces between the teeth of the wheel to be cut. Inv. 1857–5.

98. WORM GEAR CUTTERS. Contributed by R. Bodmer, Esq., 1857.

These milling tools, for cutting worm wheels, were patented by Mr. Bodmer in 1839. The cutter or "hob" is a steel worm identical in shape with the worm with which the required wheel is to work; it has, however, teeth formed on it similar to those of an ordinary milling cutter. The worm-wheel and the cutting worm are rotated at their correct relative speeds and fed into contact; the cutting worm then excavates the spaces required for the threads of the actual worm to engage in, and leaves accurately formed teeth of the correct shape for gearing with the worm. As the cutting proceeds, the milling worm is fed further into the wheel, until the required depth of space is obtained.

Inv. 1857–6.

99. WOODRUFF'S KEYS. Lent by the Woodruff Keying Co., 1892.

These keys are intended for general use in securing wheels, &c. to shafts and also for cases requiring a feather key.

The key consists of a segmental disc of steel, and the keyway in the shaft is milled out to the same curvature and width as the disc, but shallower by the amount to which the key should project. Such keyways are very cheaply formed by the special milling machine illustrated, in which the milling cutter spindle can be fed down by a lever until the regulation depth, as determined by a stop, is reached. The keys are of standard sizes, agreeing with the cutters employed and a key will adjust itself in its bed so as to correspond with any taper given to the keyway in the wheel or boss. Several sizes of keys and cutters are shown, and also an adjustable stay for supporting a shaft while the keyway is being cut.

M. 2471.

100. MACHINE VICE. Presented by Charles Taylor, Esq., 1909.

This is an example of the machine vice patented by Mr. G. B. Taylor in 1884. It consists of a long bed, with a central slot, wider at the bottom than at the top, having a fixed jaw at one end, and a loose jaw which can slide along it and also swivel to take taper work. Teeth are cut across the bed, and a gripping piece, having a tightening screw passing through its upper part, engages with these. The point of the screw bears upon a hardened piece let into the back of the loose jaw. This arrangement makes the vice quickly adjustable and brings the screw pressure directly behind the jaws. The jaws are fitted with loose faceplates which bear upon inclined faces and are free to slide downward against the action of springs, so that, when the vice is tightened up, the work is automatically pressed firmly down upon the bed.

This specimen has jaws 4 in. wide and 1·25 in. deep; it will take work 9 in. wide between the jaws. M. 3685.

101. FLAT MAGNETIC CHUCK. Lent by H. M. Budgett, Esq., 1919.

This chuck is a powerful electro-magnet, similar in principle to the rotary chuck No. 63. It is mainly of use in dealing with small articles otherwise difficult to hold, and is largely used in grinding or planing machines where only a light cut is to be taken.

The heavy iron casing is cast hollow with a number of oblong cores placed transversely and projecting upwards from the bottom of the chuck to fit within slots in the cover plate. The small annular clearances between the cores and cover plate are filled with a non-magnetic metal, and the magnetising coils are wound round the cores. The leads are taken from the chuck by flexible cable, through a double pole reversible switch, to a lamp or wall plug adaptor.

These chucks are made in a variety of sizes up to 68 in. by 14 in., and the larger sizes are provided with light dogs which assist to hold the work for heavy cuts. Being waterproof the chucks may be used for wet grinding.

Inv. 1919–259.

GRINDING MACHINES.

102. MODEL OF DOUBLE GRINDSTONES. (Scale 1 : 4.) Contributed by Messrs. Wm. Muir & Co., 1858.

This arrangement of workshop grindstones was patented by Mr. William Muir in 1853, and is a simple means of keeping them true. The two stones are mounted on parallel shafts in the same trough and in contact with one another, but they are made to revolve at different velocities so that at the point where their peripheries are in contact there is a mutual rubbing action that tends to keep them cylindrical. To prevent grooving a lateral motion is also given to one of the stones by a worm and wheel that rotates a cam that gives this motion to the axle of the stone. As the grindstones wear down, the bearings of their shafts are caused to approach each other by a pair of right and left handed screws. Inv. 1858–12. S.M. 623, L.S.

103. EMERY WHEELS. Contributed by D. Fisher, Esq., 1866.

These are samples of composition wheels, patented by Mr. Fisher in 1856, for grinding and sharpening tools. Samples of the composition in the form of bars and rods, to be used as files, are also shown. M. 1014. Inv. 1866–60.

104. WORKSHOP TOOL-GRINDER. Lent by Messrs. Luke & Spencer, 1890.

In this machine an artificially prepared emery disc is employed in place of a grindstone and is run at a surface speed of 3,000 ft. per min. A small centrifugal pump, driven by the machine, maintains a continuous supply of water on the grinding surface to keep the tool cool. Emery discs are cleaner and safer in their action than a grindstone and remain true much longer. When trueing-up is necessary, a tool holding a small black diamond, and carried in a slide which can be clamped to the table, is employed; but, as a surface speed of only 100 ft. per min. is then desirable, gearing and a handwheel are fitted for giving this lower speed. For rapid grinding, the rougher surface left by the rotary steel hacking cutter is more effective than that left by the diamond.

M. 2294.

105. ELECTRIC GRINDER. Lent by the Consolidated Pneumatic Tool Co., Ltd., 1911. Plate III., No. 6.

This is a small portable grinding machine in which the emery wheels are mounted directly on the shaft of an electric motor; it is used for cleaning castings, &c. The motor is completely enclosed in a casing, to which two controlling handles are fitted, and the emery wheels, fitted on to the projecting end of the shaft, are covered by a hood. The cable is attached to the main handle, and a switch, normally held off by a spring, is fitted close to it. The motor is wound for a current of 220 volts, and takes wheels 5 in. diam.

M. 3922. S.M. 495, L.S.

106. " DUMORE " TOOL-POST GRINDER. Lent by the Canadian-American Machinery Co., Ltd., 1919.

This is a small portable grinding machine, patented by the makers in 1917. It consists of a high-speed electric motor which carries external and internal grinding wheels, and is provided with a shank by means of which it may be held in the toolholder of a lathe or other machine.

The external grinding wheel is mounted directly on one end of the armature shaft, which runs at 10,000 revs. per min., while the internal wheel is mounted on a countershaft, driven from the other end of the main shaft by an elastic belt at 30,000 revs. per min. Ball bearings are used throughout. The lower part of the motor casing is fitted to a double V-slide, along which it can be fed by a screw and handle. The shank is secured by a single bolt to a lug on the under side of the slide so that it can be set at an angle. The grinder shown uses direct current at 220 volts and is fitted with a flexible cable, switch and lamp adapter.

Inv. 1919–339.

107. " FONTAINE " SAW-SHARPENING MACHINE (working). Lent by Messrs. Geo. W. Goodchild and Partner, 1912.

This is a machine for automatically sharpening small metal-slitting circular saws.

The grinding wheel rotates in stationary bearings, while the saw is mounted horizontally on a sliding table that receives a reciprocating motion to and from the wheel. The saw is fitted to a conical mandrel which is mounted on a vertical spindle provided with adjustments for setting it; the edge of the saw rests on a solid abutment fixed to the table. The saw is fed round, tooth by tooth, between the grinding strokes, by a spring pawl engaging with the teeth; this pawl is pivoted to the end of one arm of a bell-crank lever which receives a rocking motion from a swash plate fitted to a pulley on a short shaft. The stroke of the pawl is varied by a screw that sets the swash plate at various angles with the shaft. The other arm of the bell-crank engages with a slot in a block attached, by means of a screw, to the slide carrying the saw; by this means the saw can be accurately set up to the wheel. An arrangement is provided for obviating backlash between the arm and slot. The emery wheel and feed pulley are driven by belts from a countershaft fitted with fast and loose pulleys.

The machine takes saws up to 6 in. diam. by 0·094 in. thick and 0·187 in. pitch. The mandrel fits saws with holes from 0·375 in. to 0·56 in. diam.

M. 4119.

108. GONIOSTAT. Made by Messrs. Holtzapffel & Co. Received 1912.

This is a small instrument for the accurate grinding of lathe tools, &c.

The tool to be sharpened is placed in a holder which is held by a thumb-screw in an arm pivoted at its lower end to a plate. The upper end of this arm is pointed and moves across a scale marked in degrees. It may be clamped in any position by a screwed nut which passes through a curved slot in the plate and in this way the inclination of the tool in one plane is set. The plate carrying the tool-holder is pivoted at its lower end in a fork in the frame of the instrument, whilst at the upper end a circular arm attached to the frame passes through a slot. This arm is divided in degrees and the frame may be fixed at any inclination at right angles to the first by tightening a thumb-screw.

The frame is provided with two projecting feet which rest on a board, while the tool point rests on an oilstone slab or lapping plate let into the board.

M. 4064.

109. SAND-BLAST APPARATUS. Lent by Tilghman's Patent Sand Blast Co., 1893.

The sand-blast consists of a jet of steam or compressed air carrying with it in suspension a quantity of sand or other abrading material, which, on account of the high velocity attained by the solid particles, cuts away almost any hard substance upon which it is directed. The sand need not be as hard as the material to be cut, for it is found that a sand-blast will work its way through a plate of corundum, and a jet of small shot will depolish sheet glass. The device is used for removing the skin from metal sheets and castings, for sharpening files, and for perforating or depolishing glass or stone, any desired pattern being obtained by shielding the parts that are not to be acted upon by stencil plates of paper or other yielding material.

In the original apparatus, introduced by Mr. B. C. Tilghman in 1873, the sand was placed in a hopper connected with a pipe, within which a steam or air jet passed. The sand was drawn into the blast by the inductive action of the jet, and then blown out of the end of the pipe against the surface to be acted upon. When steam was used it was found that the moisture caused the sand to clog, and also injured the stencils, so that compressed air was generally used, although much more costly than steam.

In 1884 Mr. J. E. Mathewson introduced the arrangement shown, in which, while the velocity is given to the sand by a steam jet, the steam is at once carried off, a jet of dry sand only being projected upon the work. The apparatus consists of a cylindrical vessel with a hopper at the top, which is provided with various covers to suit the work in hand. Those shown are chiefly for supporting bottles while being stencil-marked by this process. The sand-blast passes centrally upwards, discharging itself in the centre of the hopper, but by the exhaustive action of a steam jet in a chamber below, the steam is carried away, and only the sand particles reach the work. The nozzles used are of chilled cast-iron, but where a wide thin jet is required, as for file-sharpening, durability is secured by employing three long orifices, the central one to supply the sand, and the two side ones the steam or air. The destructive velocity is not given to the sand until it has left the orifices and been picked up by the two converging steam jets. M. 2541

ENGRAVING MACHINES.

110. ENGRAVING MACHINE. Woodcroft Bequest. Received 1857.

This machine is intended for drawing or engraving on a flat surface a representation of an object that is in relief, such as a medal. It was developed from a machine made in the middle of the 18th century, in which a tracing point passing over an object transmitted its motion to a point on a plane at right angles so as to draw a cross-section of the object. By suitable feeds in both planes, a series of cross-sections could be drawn; the effect upon the eye caused by the minute variations in space between the lines so drawn, is that of an appearance of relief, as pronounced as in the original. The copy is distorted, however, by an amount which at any point is equal to the height of that point above the base line.

In 1830 Achille Collas, of Paris, influenced by the engraver's ruling machine (*see* No. 112), brought out a new design in which distortion was reduced; with this a large amount of actual work was done.

The machine shown is of this type. There is a cast-iron bed on three points of support; it has two V-guides, on which slide two tables at different levels, moved simultaneously by a right and left handed screw of 20 threads per in.; a hand lever and ratchet wheel of 120 teeth feeds the screw by amounts between 0·0004 in. and 0·01 in. Above and transverse to the guides is a frame, which supports and guides a light 3-wheeled carriage holding a braced frame, which has a diamond-tipped engraving point. This frame is hinged to another frame carrying a feeling point to touch the copy placed on the lower table. This latter frame rocks on pivots in the carriage and constitutes an equal-armed lever. When the feeler passes over the copy it rises and falls, therefore, on a cylindrical surface and not in a vertical plane, while the graver receives an equivalent motion. A cam to lift the graver out of action and a milled screw to lock the feeler are provided. The diamond point cuts through the " ground " on the surface of the copper plate placed on the upper table. The lines so exposed are bitten in by nitric acid and the plate can then be printed from. Some prints from plates prepared in this manner are shown.

Similar mechanism, for copying medal and relief work, is used at the present day in the form of an attachment to the engraver's ruling machine; it can be arranged to give also an enlarged, reduced, or reversed copy.

Inv. 1857—21.

111. ANAGLYPTOGRAPH. Presented by G. H. Makins, Esq., C.B., F.R.C.S., 1909.

This is a small example of the medal-engraving machine as modified by John Bate, and patented by him in 1832, so as to diminish the distortion which resulted from the ordinary machine (*see* No. 110); this distortion, however, is only noticeable when the object being copied is in high relief.

The construction is very similar to No. 110, except as regards the copying mechanism. The feeler is fixed to the end of a trapezoidal bar, moving in roller guides at an angle of 45° to the bed. As the feeler passes over the copy it rises and falls, therefore, in a plane inclined at that angle, the property of which is that the horizontal component of the movement equals the vertical. The horizontal movement is transmitted by a lug on the bar to a friction roller centred on an equal-armed lever, the lower end of which has a hinged frame carrying the graver. The graver, therefore, draws sections, taken on a plane inclined at 45° projected on to a vertical plane, so that the true height is given and every point occurs in its correct position, while the effect on the eye is retained. There is a rod for raising the graver out of action. The feed of the table can be varied between 0·0005 in. and 0·0125 in.

Copper plates, and prints from them, prepared with this and the adjoining machine (No. 110), are shown for comparison and information.

M. 3633. S.M. 239, L.S.

112. ENGRAVING MACHINE. Presented by Mrs. H. T. Ryall, 1896.

This is a small lining machine, designed by Mr. H. T. Ryall, the engraver, for filling in skies on steel or copper plates, the ruling and spacing of such parallel lines being exceedingly difficult without some mechanical assistance.

The machine consists of a wooden frame, supported at the four corners so that long plates can be worked upon; upon the frame as a guide slides a saddle, and along the saddle slides a small carriage that carries the graver. The carriage is moved to and fro by the pull of a band moved by a pulley and winch handle at the right-hand side, the carriage being kept down on its guides by the finger of the left hand. A cross-bar, working in inclined slides, supports the graver clear of the plate when desired. The motion of the saddle is controlled by a lever on it, which is connected to a steel strip which works in a clamp on the frame. The clamp is tightened, and the lever moved, so moving the saddle through a small distance; the clamp is then released, and the lever moved back, and so on, a very fine feed being thus obtainable, and one of varying amount as the motion of the lever is controlled by an adjustable screw.

In later machines the motion of the carriage and of the saddle are usually both given by screws, and the general construction is in metal, and much more massive than here represented. M. 2940.

113. SAXTON'S MEDALLIC ENGRAVING MACHINE. Lent by the Society of Arts, 1899.

This is an appliance for engraving, or drawing, on a flat surface a shaded representation of an object that is in relief. A machine of this class was introduced in 1830 by Mons. Achille Collas and was subsequently used in preparing the engravings for "Le Trésor Numismatique et de Glyptique."

The machine shown, however, was made by Mr. Joseph Saxton, and it embodies an invention by which distortion of the picture is reduced; a similar modification was introduced and patented in 1832 by Mr. John Bate (*see* No. 110).

The machine consists of a base, upon which a work table can be moved horizontally by a leading screw with a ratchet wheel feed, which can be made as fine as 0·0003 in. if required. The tracing and engraving points are mounted on a carriage which is slid to and fro by hand along a triangular bar guide above the tracer; the tracer is attached to one arm of a bell-crank lever carried by this slide, and the other arm of the lever carries a light frame containing the graver. By this arrangement the vertical motion of the tracer, due to relief in the copy, causes an equivalent horizontal displacement of the graver; it was by a modification in the form of the bell-crank and by the use of an oblique tracer that the distortion previously resulting was avoided. In the return stroke of the carriage the tracer and engraver are lifted clear of the pattern and plate, respectively. From there being no means of putting pressure on the graver, it is probable that the resulting plate was subsequently etched.

The work table carries two face-plates, geared together by an intermediate wheel, so that corresponding angular adjustments can be immediately effected on each; numerous other accessories are provided, which, together with a sample of the work, are also shown. M. 3071.

114. ENGRAVING MACHINE. Lent by the Deputy Master of the Royal Mint, 1910.

This machine, for producing a reduced copy in relief of a medallion or similar object, was made about the year 1830 by William Wyon, R.A., chief engraver at the Mint, 1828–51, for use in preparing the steel master-punches from which the dies for stamping coins or medals are made; the use of such a machine greatly reduces the work of the engraver. Crude machines for producing copies of medallions appear to have been in existence during the 18th century, but the machine shown is almost identical with that invented by Mons. Hulot, a French mechanician, about the year 1800, and called the "tour à portrait."

The machine is in principle a copying lathe, in which the original and the copy are mounted in the same plane, on the ends of parallel horizontal axes which are coupled together and rotated at the same speed. A bar, pivoted at one end on a universal joint, passes in front of these and has mounted upon it a tracing point and a cutting tool, which are set opposite to the centres of the original and the copy respectively. While the medallion and copy are revolving the tool bar is gradually lowered so that the tracing point traverses the surface of the original from the centre to the circumference, moving inwards and outwards as it encounters the various features of it. The cutting tool also traverses the face of the copy in a similar manner, but the distances moved through, both transversely and horizontally, are reduced in the ratio of the distances of the tool and tracer from the pivots of the tool bar, thus producing a reduced copy of the original as nearly like it as the necessary size and shape of the tracer and tool will permit.

The machine has a brass bed, secured to the top of a wooden table, and on this is mounted at the right-hand end a transverse shaft occupying a fixed position and carrying the original. The copy is mounted on a headstock, which carries another shaft at the same height, and slides upon the bed; it may be secured at any position lengthwise in order to provide for reduction in any desired proportion. The two shafts have plain bearings and are held endwise between collars; they have, fixed at the middle of their length, equal worm wheels which engage with worms mounted on a longitudinal shaft driven by a pulley and belt from a treadle-driven flywheel beneath the table. The worm shaft is provided with thrust collars, and its bearings have vertical adjustment so as to eliminate any backlash in the worm gearing. The worm that drives the movable shaft is fitted with a feather key and slides along its shaft.

At the left-hand end of the bed is a frame containing a vertical screw passing through a nut in which is mounted a horizontal pivot which has a flat square head having attached to it a flat bar upon which slides a block provided with top and bottom centre holes; another block, having a square hole through it, is pivoted to the first by means of two pointed screws that enter these holes, and the tool-carrying bar passes through it and is secured at its correct position by a clamping screw. Thus, the tool bar is mounted so that it can move freely both horizontally and vertically about its pivots, but, while the horizontal axis is fixed in position, the vertical one is adjustable sideways so that, if set to the right or left of the horizontal axis, the relief of the copy can be reduced to a greater or less extent than the diameter, as is sometimes desired. Holders carrying the tracer and tool embrace the square bar, and are clamped to it by screws at the required positions.

At the right-hand end of the table is a transverse shaft, having at its rear end a toothed wheel which gears with a smaller wheel mounted on the end of the shaft that carries the original. On the front end of this shaft a worm is fitted that engages with a worm wheel fixed to the lower end of a vertical screw which is held in bearings at its ends; a nut, threaded on this screw, slides on vertical guides, and has projecting from it a horizontal pin upon which rests a roller mounted on the end of a curved bar forming an extension of the tool bar. Thus, when the lathe is set in motion the original and copy revolve, and this screw, being also rotated, gradually lowers the nut together with the bar, tracer and tool; the latter are held up to the work by a weight attached to the end of the bar by a cord passing over a pulley fixed to the nut.

One or more cuts are taken over the copy, using a coarse tracer and tool, the number depending upon the material that is being operated upon, while light finishing cuts are taken with a finer tracing point and a very sharp tool. It is necessary, for producing an accurate copy, that the points of the tracer and tool should be set exactly opposite the centres of their respective shafts, and in line with the pivots, while the tool point should be as fine as possible. Between the cuts, the feed worm is removed and the tool bar is raised by turning the screw by hand. The earlier cuts are taken with a coarser feed than the later ones, worms with a larger number of threads being used.

The machine shown is also capable of producing a copy equal in diameter to the original but with reduced relief, and for this purpose the tool bar pivot is lowered at the same rate as the right-hand end of the bar, by means of similar mechanism.

The medallion used as the original, which is made as large as possible, would be a reproduction of the artist's design, made in a material sufficiently hard to withstand the rubbing of the tracing point. This and the material upon which the copy is to be formed are mounted in suitable chucks screwed on to the ends of the shafts. The copy when taken from the machine requires touching up by hand in order to finish those parts which the machine is not able to reproduce exactly. M. 3720

115. DIE-SINKING MACHINE. Lent by the Deputy Master of the Royal Mint, 1910.

This is a machine for producing reduced copies in relief of medallions, &c., patented by Mr. C. J. Hill in 1866, and used for preparing the steel master punches from which the dies for stamping coins or medals are made. The machine is similar to No. 115, in that the original and copy are mounted on parallel axes, coupled together and rotated at equal speeds, while the tracing point and cutting tool are mounted on a pivoted bar passing over them; in this machine, however, the shafts are placed vertically, the original and copy eccentrically to the shaft centres, and the engraving tool consists of a small rotating cutter driven at a high speed by a gut band. The tool bar is moved across the work by hand, instead of by mechanism, and the rotary motion of the original and copy, which in this case merely gives the feed, is very slow and only covers a small portion of a revolution. The machine is adapted for using originals of larger size which have the advantage that any slight defects in them disappear on reduction; also the rotating cutter, the shape of which is similar to that of the tracer and in correct proportion, will produce a more exact copy than the lathe tool. The copy may, moreover, be operated upon locally, the feed and speed of traverse being adjusted so that the tracing point can follow closely the most intricate features of the original, which point chiefly determines the accuracy and finish of the copy.

The machine has a horizontal cast-iron bed supported on standards, with a driving treadle and flywheel below. At the left-hand end of the bed is a headstock, upon which are mounted the pivots for the tool bar, the horizontal axis being adjustable in position. At the right-hand end is a fixed saddle carrying the vertical spindle upon which the original is mounted, and between the headstock and this saddle is a sliding saddle carrying the spindle upon which the copy is placed. These spindles have coned bearings at the top and back centres below, so that they are adjustable for wear; they carry equal worm wheels near their upper ends, and these engage with a horizontal longitudinal screw, the bearings of which are pressed by springs so as to hold the screw tightly against the worm wheels. The right-hand spindle has a balanced faceplate at its upper end, and upon this is fitted eccentrically an adjustable chuck in which the original is fixed; a pillar rises above the centre of the spindle, which serves as a rest for the tracer when adjusting the centre of the other spindle to the cutter. The left-hand spindle has an ordinary bell chuck, which is bolted to a faceplate screwed on to its nose, and in this the copy is suitably mounted in a similar position to the original. The longitudinal screw is rotated, through a cone clutch, worm gearing, and a variable speed gear consisting of a belt and two cone pulleys, from a pulley on the treadle shaft; it may also be alternatively rotated, more rapidly, by a handwheel, when it is required to reverse the motion or to adjust the work. The tool-carrying bar consists of two flat bars set on edge and bolted together with distance pieces between them at the ends. The left-hand end is pivoted between two vertical screw points mounted on another piece, which is itself pivoted about two horizontal screw points; a lever fixed to that piece has a cord leading to an adjustable spring, which balances the weight of the bar. At the other end of the bar is bolted a frame carrying a vertical adjustable spindle, which has the tracing point fitted to its lower end, and also a handle for traversing the bar. The cutter-frame carries the bearings for the rotating spindle, in the lower end of which the cutter is clamped, and guide pulleys for the driving band. It slides along the double bar, being moved by a pinion gearing with a rack on one of the bars, and is fixed in position by clamping screws. The driving band is passed round the rim of the flywheel and thence round guide pulleys to the cutter spindle, a weighted jockey pulley being fitted to allow for the motion of the tool bar.

As the cutting tool and tracer are constantly wearing and require to be removed and replaced, accessories are provided, by means of which they can

be replaced in exactly the same relative positions. These consist of a small plane surface, mounted on the top of a pillar bolted to the bed, upon which the tracing point is made to rest, and a long spring lever, mounted on an adjustable table, also bolted to the bed. The point of the tool rests on the lever near the fulcrum, and is so adjusted that the free end of the lever is just out of contact with a fixed plate. Means are also provided for determining whether the cutter point is of the correct size. A piece of wax is placed on an adjustable stand attached to the setting table, and a sliding block, having a triangular ridge across it, is mounted on the same pillar that carries the plane surface. While the cutter is rotating, the tracing point is placed alternatively on each side of this ridge, and the block is moved sideways through a distance equal to the width of the ridge. If the cutter is of the correct diameter, and is cutting to the correct depth, it will drill holes just touching one another at their circumferences.

Roughing cuts with a rose-cutter and a large tracer are taken first, and light finishing cuts are made with a finer tracer and with flat drill-shaped cutters having semicircular ends, which are accurately ground to shape on special machines. Adjustable arm-rests are provided for the operator. The originals used are iron castings taken from plaster casts made by the artist. The copy, when removed from the machine, is finished by hand by the engraver.

M. 3721.

116. SPECIMENS OF DIES FOR COINING. Made by William Wyon, R.A., 1842.

These specimens illustrate the mode of preparing dies for medals or coins, and were made by Mr. Wyon, then chief engraver at the Royal Mint, in 1842. The engraver first produces a steel master die, in intaglio, known as the matrix; this is hardened and used to produce, by pressure, a reversed copy called a punch, the steel being frequently annealed during the process. This punch then serves to make any number of working dies in a similar manner, dates and lettering being put on these by hand. The working dies are turned parallel for a short length and are surrounded, in the press, by a steel collar which prevents the coins from spreading laterally.

In modern practice the matrix is produced, by pressure, from a master punch made on an engraving machine such as No. 114 or No. 115; the work of the engraver is thus largely reduced. M. 3769.

SCREWING MACHINES AND APPLIANCES.

117. SCREW STOCKS, DIES, AND TAPS. Contributed by Messrs. Joseph Whitworth & Co., 1857.

These tools embody the improvements patented by Sir Joseph Whitworth and John Spear in 1840.

The set of dies consists of three pieces, a wide one which acts chiefly as a guide, and two narrow ones which act as true cutting tools or chasers. The two cutting dies have each one cutting edge, but one cuts during the right-handed rotation and the other with the left. Both dies are simultaneously closed in radially by a notched cotter, which is tightened up by a nut as the screwing advances. The master tap, by which the dies are cut, is made larger in diameter than the ordinary tap by twice the depth of the thread, so that when commencing to screw, the dies touch all round the rod to be screwed, and are therefore certain to start a true thread. As the screwing proceeds, the dies act more and more by their corners or cutting edges only, so obtaining " relief " to the cutters, and improving their cutting power. Dies for various threads can be fitted in the stock, and they are held in position by a removable cover-plate.

The taps are formed with three wide longitudinal grooves milled in them, the section left being such as to give three true cutting edges of 90°, and the necessary relief is obtained by " backing-off " the thread following the cutting edges. The shank of the tap is reduced so that it will pass through the hole tapped. The master taps shown have eight narrow grooves, owing to the dies to be cut being in pieces.

The adoption of the Whitworth standard screw threads which gave the present uniformity was hastened by the superiority of this tackle over that formerly in use. Inv. 1857-8.

118. SCREW TAPS. Contributed by R. Bodmer, Esq., 1857.

These " convolute " taps, patented by Mr. Bodmer in 1841, are very similar to those of Whitworth. The top of the thread is eased in a convolute form, and the bottom and sides of the thread are also tapered and relieved in the same way, so that the tap may cut like an ordinary turning tool. Inv. 1857-7.

119. SCREWING MACHINE. Contributed by W. E. Newton, Esq., 1861.

This is a screw-cutting machine, patented in U.S.A. by Messrs. Moore & Madison in 1856, for cutting screws by hand or by power. The dies are held in a clamp which slides freely on two fillets, one on each side of a trough. The clamp is provided with a screw and a graduated scale for closing and setting up the dies, and a lever and latch for quickly opening them. The rod or bolt-blank to be screwed is held in a pair of jaws like a lathe chuck, and is caused to rotate. The machine can also be used for tapping nuts, a cross bar with a square recess or socket being then used to hold the nut stationary, and the tap being held by the jaws and rotated. Inv. 1861–51.

120. SCREW ROLLING MACHINE. Contributed by Mr. Elliot, 1860.

This machine, patented in 1851, is intended for making single or multiple screw threads of different diameters from the same set of dies, and for producing the thread, whether square or angular, by rolling compression. Two steel plates or dies, having on their faces longitudinal grooves of the shape and pitch of the required screw thread, are placed one above the other at a distance apart suitable for the diameter of the screw. The upper die is attached to a block which can be raised or lowered by a screw, and the lower one is attached to another block which slides in horizontal guides and receives a reciprocating motion from a crank and connecting rod driven through spur gearing. The dies are adjustable in their blocks and are set so that their grooves are inclined at opposite angles to the direction of motion of the lower die, equal to the angle of the required thread. The rod or blank is placed between the dies, the upper one forced down upon it, and motion given to the lower one whereby the blank is rolled between the faces. Specimens of the screws produced by this process are shown. Inv. 1860–54. 20,888, L.S.

121. SCREW GAUGES. Lent by Messrs. Taylor, Taylor & Hobson, 1893.

These specimens show the system of standard gauges introduced to ensure that the screwed connections of photographic apparatus shall be interchangeable.

No. 1 is a double calliper gauge for external threads—one side gives the standard in this case 1·5 in. diam., and the other 1·499 in. diam., the difference being the amount allowed on external screws to secure an easy fit and absolute interchangeability, any work exceeding these limits being rejected. No. 2 is a double gauge for internal screws, one end being 0·001 in. larger than the standard, so that any screw cut to it shall readily fit any screw passed by the external screw gauge. No. 3 is the chaser employed for cutting the threads, and it is equally capable of cutting both internal and external threads. It has two grooves, of the shape of the thread, cut on it externally, and is provided with a central hole by which it can be attached to a toolholder. One-fourth of the circumference is cut away, so giving two cutting edges, one of which is used for external screws and the other for internal screws.

To overcome the difficulty of entering these fine threads and also to avoid the risk of stripping them, the first half of the revolution of the thread—where it is incomplete—is cut away, so giving an abrupt commencement but a thread of full strength. The internal threads are treated in the same way, and an arrow head is stamped on the two portions so that they can be placed together in the position in which the relieved threads will at once engage. Nos. 4 and 5 show a pair of threads so treated. No. 6 is a standard screwed ring in steel provided with an index mark on each side. Its thickness is such that, when screwed on, the index marks the commencement of the complete thread, so that by marking and finishing fittings to this gauge it is secured that all fittings shall screw up to the same position, thus ensuring that lenses or diaphragms shall occupy their intended parts in any camera. M. 2551.

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122. PARALLEL VICE. Lent by J. Parkinson, Esq., 1890.

In this vice, patented by Mr. J. Parkinson in 1885–6, the screw travels with the front jaw and, by a lever at the side, the stationary half-nut which locks into the screw can be lowered out of gear, allowing the vice to be quickly opened or closed to its full extent, while when the nut is permitted to engage, the necessary powerful grip is obtained by a slight turn of the screw. A spring is fitted which presses the nut into gear and the thread employed is of the buttress form. The front arm having a simple sliding motion, the jaws always remain parallel. M. 2349.

123. CAULKER FOR PIPE JOINTS. Presented by C. Wheeler, Esq., 1883.

This is a tool, patented by Mr. Wheeler in 1882, for caulking joints in pipes. A heavy ring slightly larger than the pipe, in two halves joined together embracing the pipe, carries three caulking tools. By sliding the whole on the pipe the tools are driven against the lead in the joints to be caulked. M. 1545.

124. ELECTRO-MAGNETIC SEPARATOR. Made and lent by the Rapid Magnetting Machine Co., Ltd., 1913.

This machine is particularly designed for separating mixed workshop turnings or filings, but it acts on the same principle as separators used for ore-dressing, pottery clay cleaning, &c.

The electro-magnets are fixed on a segmental yoke within a revolving renewable brass drum, fed from a hopper by a cam side-shaken tray with comb edges. The drum is provided with transverse ledges, and as the magnets are of alternately reversed polarity, the magnetic particles keep turning over, thus effectively releasing the non-magnetic, which drop off, while the magnetic are carried round till they are beyond the range of the magnets, when they too drop off into a separate box. It is claimed that the machine will separate a mixture of 99 per cent. iron and 1 per cent. brass, if previously sized by passing a sieve of 0·25 in. mesh.

The machine shown is the smallest size made; the speed is 160 revs. per min. The magnets are wound for any voltage desired—in this case 220 volts; the current required is 0·7 amps. M. 4210.

125. MACHINE FOR MAKING SPRING-HOOKS. Presented by Messrs. Newton & Son, 1858.

This machine was patented in 1840 by Mr. W. Church, and is for manufacturing spring-hooks for fastening clothing, of a shape patented by him in 1839.

The wire is intermittently advanced into the machine by a pair of grooved feed rollers, through an elliptical slot, where it is held by pins while a blade cuts off a piece sufficient to form one hook. The pins now bend down the ends of the wire, which curved jaws convert into eyes, but one of these is left with a long end which afterwards forms the spring tongue. A nib bearing on the middle of the wire forces it down a recess in a guide plate, while a horizontal ram moved by toggles somewhat flattens it and at the same time sets the spring tongue; on the return movement of this ram the partly finished hook drops out below. These various motions are derived from cams on a main shaft, provided with a flywheel and driven by a belt.

The blank hook thus obtained is completed in the smaller machine, called a beaker. This has a spindle which can slide longitudinally in its bearings, and which is coupled, by an inclined-plane clutch, to a pulley turning loosely on the former and reciprocated by a band from a spring treadle. The blank hook is placed on the bed, under a pin in the centre of the spindle, and on pushing down the treadle an eccentric pin on the end of the spindle bends over the end of the blank and completes the formation of the hook. A stud fixed on the spindle stops its rotation, the pulley continuing to turn, so that the inclined-plane clutch forces back the spindle and withdraws the pins from the hook, which is thus released.

The attached specimens show the stages by which the finished result is obtained. Inv. 1858-17.

126. MODEL OF PORTABLE FORGE. (Scale 1 : 4.) Received 1906.

This apparatus, patented in 1879 by Dr. J Hardinge, was designed to meet the wants of workmen engaged in outdoor repairs, and thus to avoid the delay involved in taking the work to a shop.

The hearth of the forge is supported on a metal frame, and upon the back of the standard is bolted the fan-case, which contains bearings for the fan shaft. This shaft also carried an emery wheel, a chuck for drilling, and a friction wheel by which it is driven. Attached to the frame is a shaft carrying the heavy driving wheel, and a pinion and ratchet wheel formed in one piece. On the hub of the driving wheel are one or more pawls gearing with the ratchet wheel. The pinion is driven by a toothed quadrant, which may be operated either by a treadle or a handle. A spiral spring acts as a counterbalance to the treadle. Attached to the frame is a vice and an anvil. Portions of the frame of the hearth can be removed to allow long rods to be laid in the fire. M. 3450.

127. MODEL OF WHEEL-MOULDING MACHINE. (Scale 1 : 4.) Lent by Messrs. Wm. Whittaker & Sons, 1901.

This construction of machine for preparing the sand mould necessary for casting a spur wheel without the aid of a complete wooden pattern was patented by Mr. John Whittaker in 1869, and subsequently improved in detail.

When used for preparing wheels from 3 in. to 5 ft. diam., a pattern representing two consecutive teeth is secured to an external arm by which it can be lowered into a moulding box resting on a table capable of being accurately rotated by means of a large worm wheel and a worm, which serve as a dividing engine. The interior of the moulding box is rammed up and strickled to a smooth cylindrical surface by a sweep turning on a central post, and the tooth pattern is then placed in position and retained by the arm while sand is rammed into this space. The pattern is then steadily lifted by the mechanical slide by which it is connected to the arm, and, when completely above the mould, the table is, by the dividing arrangement and change wheels, rotated the amount corresponding with the number of teeth required; the tooth pattern is then again lowered and sand rammed up as before, until the mould for the complete series of teeth has been thus prepared. The mould is afterwards finished by the insertion of four or more masses of rammed sand supported on plates, and so shaped as to leave spaces corresponding to the rim, arm, and boss, required for the complete wheel.

For moulding the teeth of wheels that are too large for the use of a bottom box, the work is performed in the sand floor of the shop, the table of the machine with its dividing wheel being temporarily bedded in the centre of the mould and the arm with its adjustments bolted to the table, so that the dividing arrangement gives motion to the arm instead of to the box.

In the machine represented the dividing wheel is arranged under the table and boxed in, so that, with its worm, it is protected from the destructive action of the foundry sand. The tooth pattern is held by a pillar and radial arm, carried by a saddle which can be moved along a horizontal bed by a screw. The pillar is adjustable vertically by rack and pinion, and it also allows the arm to be swung to and from the nearly tangential position it occupies while the tooth space is being moulded. The length of the radial arm is adjustable by a horizontal slide and screw, while the terminal piece which carries the pattern is movable in vertical guides by a rack and pinion. M. 3195.

128. MOULDING MACHINE. Lent by H. Gibbons, Esq., 1893.

This is a machine, patented by Mr. Gibbons in 1880, for securing a straight lift when withdrawing the pattern from the sand, and so preventing damage to the mould by any unintentional movement, while, owing to the facility with which the work can be turned over, " top lifts " are avoided. For repetition work the use of such machines and plate-patterns has greatly reduced the cost of founding.

This machine consists of two turned columns bolted to a bed-plate. On each column is a sliding sleeve, carrying a bearing in which rest the trunnions of an open frame that supports the pattern plate. The weight of the frame is supported by two pitch chains, passing over wheels at the top of the columns and then down to counterbalance weights. The wheels are keyed to a common shaft, provided with a ratchet wheel to prevent running down, and a hand wheel for rotating when lifting the pattern. Clips on the plate hold the box when turned over, and a frictional grip locks the trunnions. In moulding with this machine, the plate is moved up to a convenient height, the moulding box placed on it, clipped, and rammed up. The plate and box are then turned over together and lowered till the box rests on the base, when the clips are loosened and the pattern plate, after being rapped, is lifted off the mould by the machine. The lifting chains are so attached that any slackness of the sleeves in the columns does not influence the lift, the slack being always taken up in the same direction.
M. 2535.

WOOD-WORKING MACHINES.

129. MODEL OF MACHINE FOR BENDING TIMBER. (Scale 1 : 8.) Presented by Capt. Mackinnon, R.N., and J. Draper, Esq., 1863.

In this machine a straight piece of timber, after being well steamed, is fixed by one end in a pair of jaws at one extremity of a segment turning upon a pivot.

The segment is provided with a powerful lever, having a rope atached to it' with a crab by which it can be turned. A guard-plate behind the timber keeps the tail end from springing away, while the rotation of the segment gradually bends the timber, which is then allowed to dry and set in this curved shape.

Inv. 1863–13.

CIRCULAR SAWS.

130. MODEL OF CIRCULAR SAW BENCH. (Scale 1 : 4.) Contributed by Messrs. Samuel Worssam & Co., 1864.

The date of the introduction of the circular saw is not known, but in combination with the self-acting carriage it was patented in 1777 by Samuel Miller, of Southampton; it was used there in the manufacture of ships' blocks for H.M. Navy by Walter Taylor. General Sir S. Bentham is credited with bringing the saw, at the end of the 18th century, into a convenient bench form with an adjustable fence.

The saw is formed from a disc of sheet steel; it is clamped by a nut and washer against a flange, provided with a steady pin, solid with the driving shaft. The saw, like the driving pulley, overhangs its bearings, which are underneath and transverse to the bench. Part of the table lifts out to allow of access to the nut for changing saws. The fence or guide is arranged to traverse on a screw in a slot in the table to allow any width to be cut; the fence is adjustable by three set screws at the back.

The advantage of the circular saw is its high cutting speed—6,000 to 7,000 ft. per min.; its disadvantages are its large diameter—about three times the thickness of the piece to be cut—and the waste of wood due to the thickness of the saw necessary for stiffness.

Inv. 1864–47.

131. MODEL OF CIRCULAR SAW, WITH GUARD. (Scale 1 : 4.) Lent by Messrs. R. Garrett & Sons, 1894.

This circular saw bench is fitted with rollers at each end to facilitate the placing of heavy timber. The usual adjustable fence or guide is fitted, but it has a swivel front, so that timber can be cut on the bevel when desired.

The saw is shown fitted with a guard, introduced in 1884 by Mr. J. B. Lakeman, one of H.M. Inspectors of Factories, to prevent the possibility of a workman falling against a revolving saw, or his being struck by loose pieces of timber carried round by it; it also prevents the discomfort arising from the sawdust being thrown upon the sawyer. The guard consists of a curved metal plate, provided at the front end with a flap that may be thrown back when starting to cut deep stuff. It is substantially made, and is supported by adjustable arms bolted to the table, so arranged that they can be quickly altered in position.

M. 2686.

132. CIRCULAR SAW GUARD. Presented by Messrs. M. Glover & Co., 1902. Plate III., No. 7.

This shows a half-size model of a saw bench fitted with the smallest arrangement of a form of guard, patented in 1898 by Mr. A. W. Glover, for protecting the attendant from accidental contact with the rapidly revolving teeth of the saw.

The whole of the back portion of the saw is shielded by a closely fitting stationary blade, slightly narrower than the cut made by the saw, so that it does not interfere with the passage of the timber; the front of the saw is guarded by a channel-shaped flap under which the wood to be cut is passed. Both of these guards are adjustable to suit saws of different diameters, and the front guard can be set to suit the thickness of wood being cut. The whole arrangement is carried by a vertical post turning in a bracket secured to the bench, so that it can be quickly removed or swung out of the way when not required.

M. 3248. S.M. 1266, L.S.

RECIPROCATING SAWS.

133. MODEL OF SAW-FRAME FOR SHIPS' TIMBERS. (Scale 1 : 8.) Presented by Lady Bentham, 1859.

This represents a machine, patented by Sir S. Bentham in 1793, for sawing timber into curved, bevelled, or winding forms, such as ribs for wooden ships, &c. The timber to be sawn is fixed in a frame which, as it travels along, is

moved sideways by means of a pin attached to it travelling in a slot, of the curved form required, in the stationary main framing. The movable frame is mounted upon a second frame, which is capable of rocking about a horizontal axis, so that the timber may be placed in the right position to be sawn with a bevel, or in a twisted or winding form. Specimens of the work are shown.

Inv. 1859–1. 20,522, L.S.

134. SAMPLES OF VENEER AND SMALL BLOCKS. Presented by Lady Bentham, 1859.

These examples were cut by machines patented by Sir S. Bentham in 1793. Veneers cut from hard woods of ornamental appearance, such as mahogany, rosewood, walnut, bird's-eye maple, &c., are very largely used in the manufacture of furniture, the appearance and surface of the hard wood being obtained by a thin covering of veneer glued on to a foundation of cheaper timber.

Inv. 1859–2 & 3.

135. MODEL OF RECIPROCATING SAW MILL. (Scale 1 : 10.) Made by Mons. P. Regnard, 1902. Plate III., No. 5.

The application of power to working a number of vertical saw blades stretched in a frame appears to date from the 15th century, and this class of sawing machine is still that most extensively used in Europe for converting lumber into boards and planks. It is not so expeditious as the circular saw mill, but, owing to the narrowness of the cuts, wastes much less of the timber in sawdust.

The model shows a power frame saw, made by Messrs. F. Arbey and Son, of Paris, in which only one saw blade is used. This blade is carried, in tension, between the overhanging arms of a frame, reciprocated in vertical guides by a connecting-rod from a crank pin on shafting driven by belting beneath the floor level. The log to be squared or sawn is gripped at one side by two pairs of claws, actuated by separate screws in two vertical slides or standards which are similarly adjustable across the bed of a carriage, supported on special rails and moved by a pinion engaging with a long rack attached to it. This feeding pinion is rotated continuously, through a train of reduction gearing worked by a belt on speed cones, from the first motion shaft; there is also a friction clutch controlling a quicker and reversed travelling motion for use in running back the carriage. The upper edge of the saw is somewhat in advance of the lower one, so that the teeth shall not drag through the timber in the up or non-cutting stroke; in many frame saws, however, an intermittent feeding motion is given in preference to the continuous arrangement here shown.

In oaken timber, for depths of from 12 to 28 in., the rate of feed is from 8 to 4 in. per min., or the area of the surface cut is about 100 sq. in. per min.

M. 3219. 30,896, L.S.

BAND SAWS.

136. BAND SAW. Lent by J. Barr, Esq., 1888.

This type of saw is very largely used for straight as well as curved sawing. The saw itself is in the form of an endless band, running at a high velocity over three rubber-covered pulleys, by one of which it is driven. The narrowness of the band enables the attendant to turn the work about so as to cut it in any required direction; the ends of the blade are united by brazing, and the tension is regulated by altering the position of one of the pulleys. The table can be tilted for cutting on the bevel. M. 1881.

137. BAND SAW SETTING MACHINE. Lent by Messrs. M. Glover & Co., 1911.

This is a machine for setting the teeth of band saws rapidly and accurately. It consists of a frame in which the saw blade is held by an easily adjustable clamp so as to be free to slide endwise. To this frame is pivoted a lever which is oscillated by hand in a direction at right angles to the saw; a steel plate is secured to the lower and shorter arm of the lever, and projections on this plate act upon the teeth of the saw and set them to one side or the other on alternate strokes of the lever. At the middle of each stroke the saw is fed forward by a pawl attached to one arm of a bell-crank lever, the other arm of which is acted upon by a cam formed on the lever. The pawl is returned by a spring and its stroke is regulated by a screw. Two screws, passing through lugs on the lever boss and bearing against stops on the frame, serve to regulate the amount of set. M. 3916.

138. AUTOMATIC SAW-SHARPENING MACHINE. Lent by Messrs. M. Glover & Co., 1911.

This is a machine for sharpening band or other similar saws by means of a circular file or fine toothed milling cutter rotated by hand.

The saw blade is mounted below the file in an adjustable clamp, and the file is made with a notch at one point on the circumference, in which is fitted a steel cam-plate that feeds the saw forward by one tooth for every revolution. Such a machine sharpens all the teeth uniformly and at the rate of about 4 ft. per min.

The example shown may be screwed to a bench or table and will take saws up to 1·5 in. wide. M. 3917.

PLANING AND MOULDING MACHINES.

139. DIAGRAMS OF WOOD-WORKING MACHINERY. Presented by Prof. W. F. Exner, 1877.

This series of diagrams shows the various shapes of cutters and methods of fixing them, with particulars of the numbers of cutter-heads, style of feed apparatus, &c. adopted by various English and foreign makers of wood-working machines. M. 1827.

140. MODEL OF MACHINE FOR CUTTING MOULDINGS. (Scale 1 : 8.) Wheatstone Collection, 1876.

This represents a machine for preparing mouldings of the class shown, in which the pattern undulates slightly in two directions. The timber to be worked is secured to a sliding horizontal table, driven by a rack below, which is advanced by a pinion worked by spur gear from a winch handle. On the winch shaft are two cams, one of which gives a vertical oscillation to the toolholder and the other a horizontal oscillation; the holder is held in compound guides secured to the main framing and has a screw for adjusting the depth of the cut. The cutter employed is not shown, but appears to have been a moulding iron the full width of the work; from the worked specimens preserved it appears that the compound motion of the cutter improved the cutting action of the blade. M. 1553. 19,615, L.S.

141. UNIVERSAL WOODWORKER. Lent by Messrs. T. Robinson & Son, Ltd., 1914.

This is a compact machine designed to perform a large number of woodworking operations, such as planing, surfacing, tenoning, moulding, sawing, &c.

The machine has three tables mounted on a heavy box casting. The large centre table is in two parts, each of which is mounted on an inclined slideway and may be raised or lowered by a handwheel. In the gap between them rotates a long cutter-frame carried on a spindle in bearings on the main casting. The spindle extends at one end to carry a chuck and at the other end a driving pulley and circular saw or cutter-block.

Planing, Surfacing, Chamfering, Rebating :

On the main tables timber can be planed up to 12 inches in width and the depth of cut regulated by adjusting the front half of the table. For continuous chamfering, the front half of the table is lowered to give the desired amount of cut and when stop chamfering, the back table is lowered to the same level as the front. In both cases the fence is canted and used as a guide. Rebating is carried out on the front edge of the tables, the front table being lowered for depth of rebate and the fence adjusted to give the width.

Tenoning, Thicknessing, Tonguing, Grooving and Moulding :

The second table at the back of the machine may be made to rise or fall on vertical slides, the spindle carrying the saw extending either over or under it. With the cutter-block fitted all the above operations may be performed, except tenoning. Tenons are cut by replacing the square cutter-block with a tenoning cutter-block, the timber being passed under by hand feed. After cutting one side of the tenon, the table is raised above the cutter-block and the other side cut by passing the timber over it.

Slot-mortising and Boring :

The third table, in front of the machine, is mounted on slides giving vertical, longitudinal and transverse movement. When slot-mortising, a bit is placed

in the chuck and the work clamped to the table. Two holes are bored at a suitable distance apart, and the intervening timber cut away by repeated movements past the mortising bit until the full depth of mortice is obtained.

Circular and Irregular Moulding:

For these operations a spindle is fitted which, when in use, extends vertically upwards through a circular hole in the planing table. It has a belt pulley for driving and is provided with a square cutter-block, adjustable straight and ring fences, and side pressure springs. When not in use it may be lowered and the hole in the table filled with a circular plug.

Cross-cutting, Mitre-cutting and Dimension Sawing:

For these operations the timber is carried on a sliding plate working in a groove in the edge of the table, this plate being fitted with a fence adjustable to any angle. Inv. 1914–118.

MORTISING MACHINES.

142. MORTISING MACHINE. Contributed by Messrs. M. & J. H. Buck, 1860.

This is a machine for cutting the deep grooves or slots that form the most difficult part of the work in preparing the common mortice and tenon joint, so generally used in woodwork. The chisel is controlled by vertical guides and is forced downwards by the action of a foot lever, the return upward movement being given by a helical spring; the wood to be mortised is held in a vice secured to the machine frame. By means of a screw thread in the top of the toolholder, it is caused to rotate through one quarter of a circle in the last part of its ascent, and through another quarter in commencing its descent, so that it turns half round after each stroke. Later machines of this type have the frame, &c. of cast iron and the tool moved by a counterweighted hand lever. Inv. 1860–56.

143. MORTICE CHAIN AND GUIDE BAR. Presented by Messrs. Hans Renold, Ltd., 1911.

This is a chain cutter which, used in a wood-mortising machine, produces rapidly, in one cut, a finished mortice of exact size. The machine is similar to a chisel-mortising machine, but the chisel is replaced by an endless chain cutter driven by an upper sprocket wheel and passing round the lower end of a guide bar which is mounted on a slide that is pressed downward so as to cause the chain to cut into the wood to the depth required.

The chain is built up of a number of hardened tool steel link-plates connected together by rivets which are countersunk into the outer plates; a cutting tooth, having the proper cutting angle and clearance, projects from one edge of each plate. The smaller chains have alternately one and two plates in each link, while the larger sizes have two and three, the thickness of the plates varying according to the total width of mortice required. The guide bar is also of hardened steel and has a ridge on each edge to guide the chain, while a roller bearing wheel at the lower end receives the working thrust. Its upper end is bolted to the slide of the machine, and above it the driving sprocket is mounted.

The example shown cuts a mortice 0·25 in. by 1·5 in. and 4·5 in. deep; its sprocket has four teeth and should run at 2,500 r.p.m., giving a cutting speed of 1,000 ft. per min.; but for larger sizes a speed of 1,500 ft. per min. is required. Mortices of this size can be cut to a depth of 5 in. in pine in 16 secs., or in oak in 19 secs. The chains are made in ten English and eight metric widths between 0·25 in. and 1 in. M. 3983.

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144. MODEL OF COPYING LATHE. (Scale 1 : 5.) Made by MM. Regnard Frères. Received 1892. Plate III., No. 8.

This represents a lathe for turning articles whose form is irregular and section not circular, such as wheel spokes or gunstocks; the model is shown shaping a table leg.

The machine consists of an ordinary slide-lathe bed carrying two double headstocks, so forming two lathes with parallel axes. The front lathe is driven by a stepped pulley in the usual way, and by an intermediate wheel drives the back lathe in the same direction and at the same speed. A saddle slides on the bed, and carries a slide upon which stand two stout swinging levers connected above by a tie-rod. To the front lever is attached a turning tool, and to

the back one a blunt finger. In the back lathe is fixed an iron pattern of the shape desired, and in the front lathe is the work to be turned. A wooden spring is shown which keeps the copying finger in contact with the work, and change wheels and a central guide screw are arranged to feed the saddle along, while a trigger gear is added which releases the feed nut when the saddle has gone far enough. Instead of a turning tool as shown it is usual to employ a rapidly revolving fly-cutter, and to substitute for the copying finger a circular roller of the diameter of the cutter path, by which arrangement a much higher cutting speed is attainable. M. 2446. 19,618, L.S.

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145. MODEL OF WOOD-CARVING MACHINE. (Scale 1 : 4.) Presented by J. Clowes, Esq., 1858.

This is a machine, patented by Mr. T. B. Jordan in 1845, for carving in wood or other material copies of busts, statuettes, &c. A table, capable of horizontal motion in either direction, is provided to receive both the model or object to be copied, and one or two blocks of wood to be carved. A frame above the table, capable of vertical motion, carries a guide-pin or feeler, with a spherical end, and two headstocks with revolving cutters. By means of the several motions described, the guide-pin is made to travel over the whole surface of the model, with the result that the wood is cut by the cutters to the same shape as the model, but fine lines or any undercutting are done afterwards by hand. Inv. 1858–6. S.M. 622, L.S.

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146. FLOORING CRAMP. Contributed by W. Bissell, Esq., 1862.

This cramp, patented by Mr. W. Bissell in 1852, is designed for setting up floor boards, framed doors, &c.

The body of the tool is a heavy iron casting, which grips the joist between a projecting shoulder and an eccentrically mounted toothed quadrant; as the pressure on the cramp increases, the quadrant tends to turn inwards and tightens its hold on the joist. The cramp having been placed in position, pressure is applied to the edge of the plank by a sliding block operated by a screw which is rotated by a winch handle through two to one bevel gearing. Inv. 1862–96.

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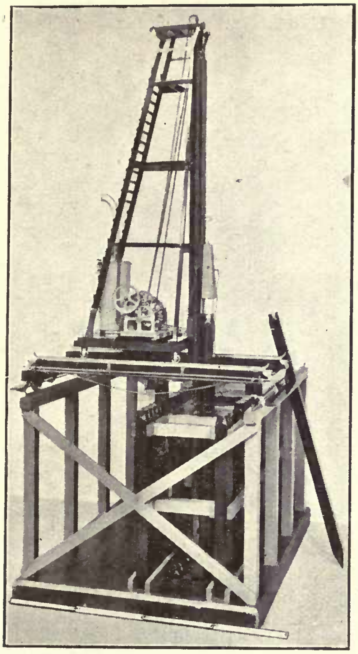

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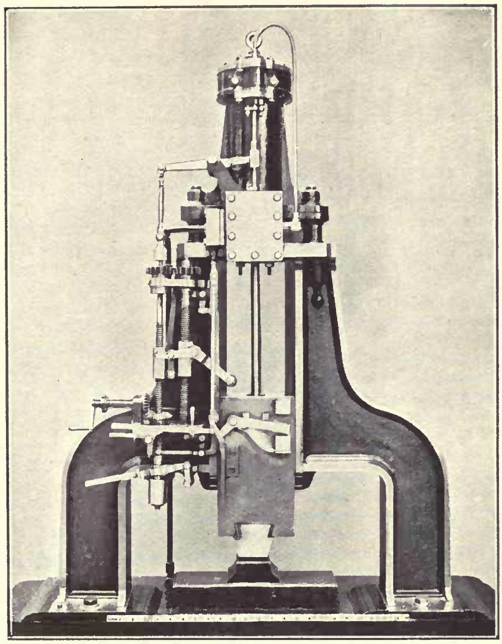

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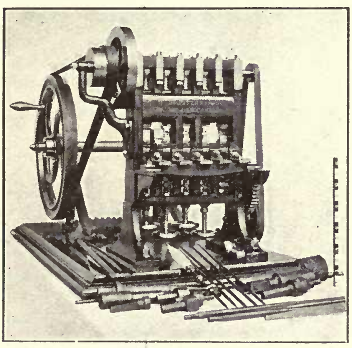

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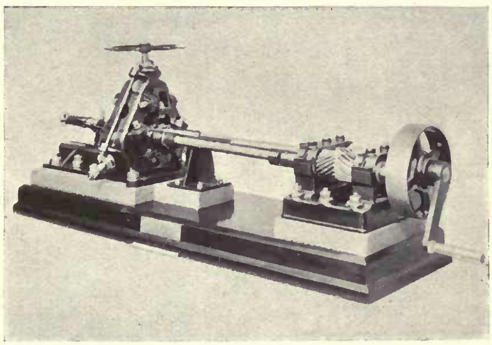

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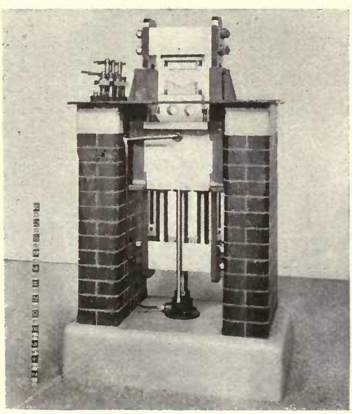

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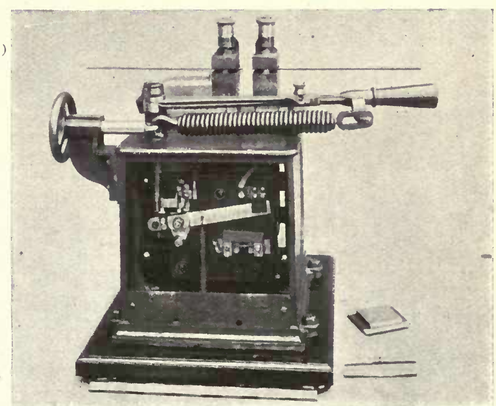

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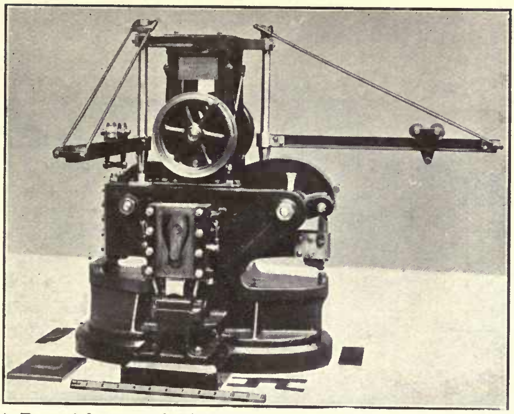

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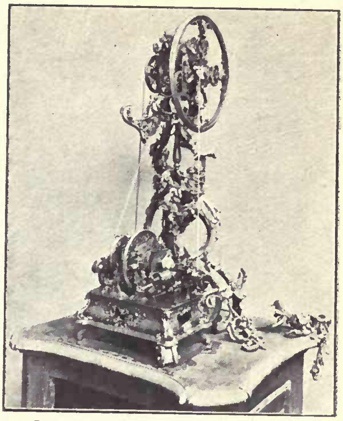

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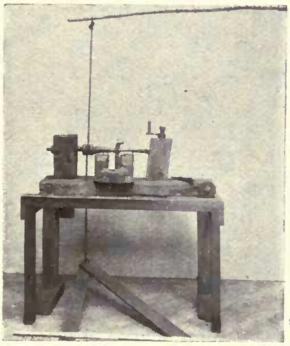

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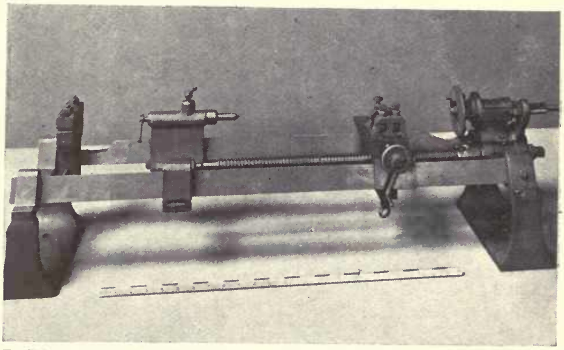

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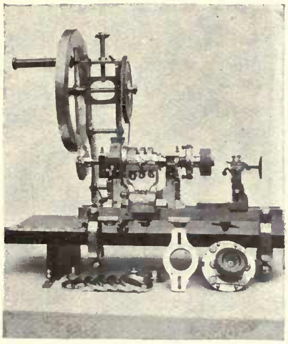

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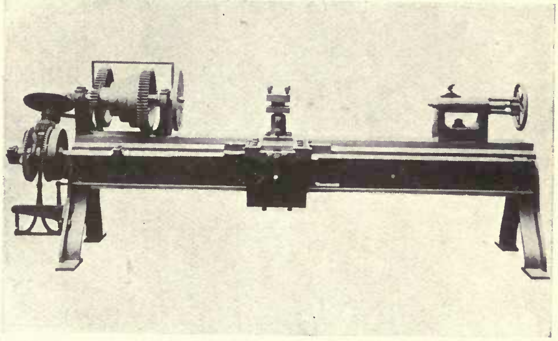

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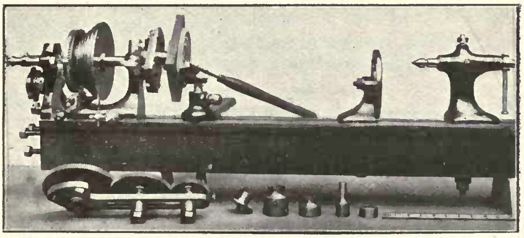

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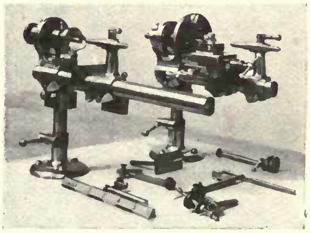

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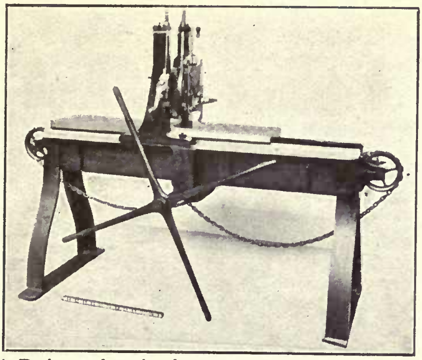

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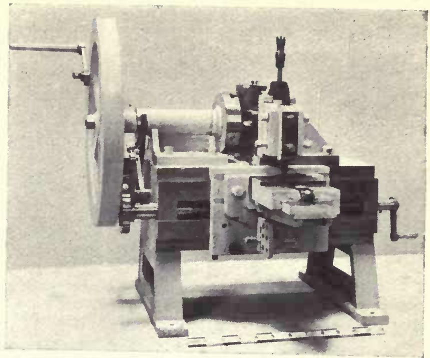

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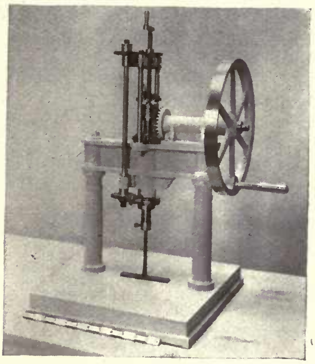

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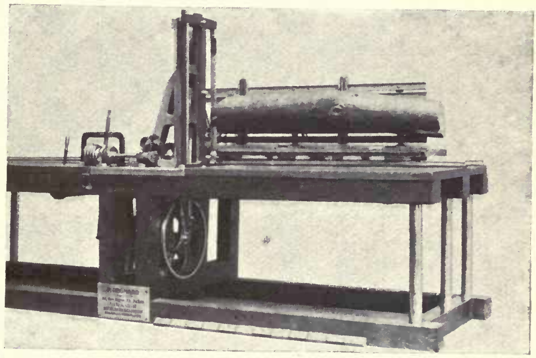

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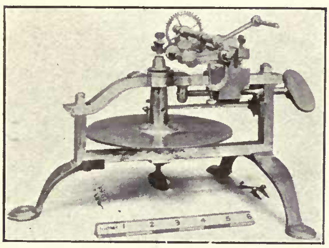

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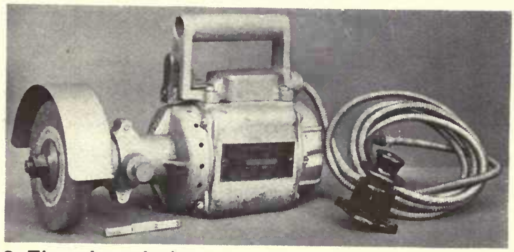

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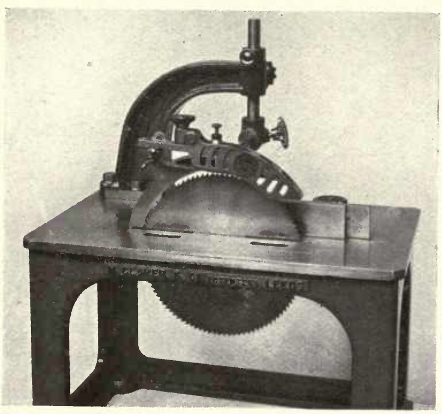

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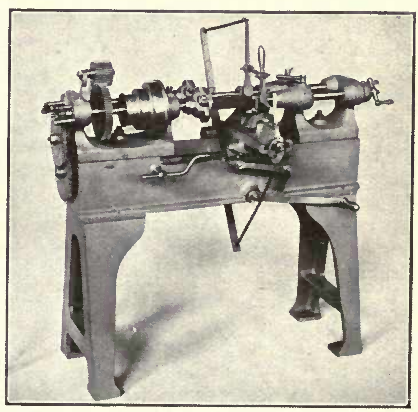

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